# A Proposed Microgrid Model For 37no Halishahar Ward Of Chattogram City Corporation, Bangladesh

by

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**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING**

Department of Electrical and Electronic Engineering
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March 2022

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A thesis
submitted as partial fulfilment of the requirement for the degree of

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# CERTIFICATE OF APPROVAL

The thesis entitled as "**A Proposed Hybrid Microgrid Model For 37no Halishahar Ward, Chittagong ,Bangladesh** " submitted by **MD Minhaj Hossain** , bearing Matric ID. **ET-173011** and **Minhazul Haque Chowdhury Tamim**, bearing Matric ID. **ET-173038** of session **Autumn 2017**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **March,2022**.

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# DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this thesis has been submitted elsewhere for the award of any degree or diploma.

MD Minhaj Hossain

Minhazul Haque Chowdhury Tamim

# ACKNOWLEDGMENT

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Authors

# ABSTRACT

Electricity has helped us by reducing physical efforts to a very large extent, but, the way in which it is produced is quite a matter of concern. Even today, most of the electricity that we use producing through using conventional methods. These conventional methods commonly use mainly fossil fuels to produce electricity. Not only are these methods expensive, but also cause huge collusion to the environment. The use of fuels for the generation of electricity results in increased costs and emissions of hazardous pollutants. The only alternative is a new method that is not only cheap and efficient but also eco-friendly. This paper focuses on the proposed hybrid (photovoltaic array, wind turbine, battery storage) microgrid model for 37no Halishahar ward of Chittagong City Corporation, Bangladesh. The photovoltaic array and wind energy systems are used to as primary energy systems and the battery is used as a backup energy system. The battery storage system is used to store extra power from the photovoltaic system and to supply continuous power to load when the PV power is not present. A Fuzzy Logic Controller based photovoltaic Maximum Power Point Tracking controller technique is used . MATLAB/Simulink software is used to model, simulate, and analyze the entire hybrid system.

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| | |
|---|---|
| PV | Photovoltaic Array |
| WT | Wind Turbine |
| FLC | Fuzzy Logic Controller |
| CCC | Chattogram City Corporation |
| HAWT | Horizontal Axis Wind Turbine |
| VAWT | Vertical Axis Wind Turbine |
| MPPT | Maximum Power Point Tracking |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

Electricity is not enough to meet the needs of people every day. This has been a big problem because there are only so many natural resources. One issue has been how fossil fuels have played a role in global warming and other climate change problems. Thermal power plants now make up 68% of all electricity, with the rest coming from hydropower plants, nuclear power plants, gas power plants, and, as we all know, fossil fuels will run out one day [1]. Solar and wind are both sources of energy that aren't going to run out of energy. Solar energy is available during the day, and wind energy is at its peak on the coast. The goal of this thesis is to help the world move away from dirty energy. The main goal of this is to make a hybrid microgrid model that makes the most of the energy and solar energy that the sun gives off and the speed of the wind gives off. So the horizontal axis wind turbine can get the most energy from the wind. We have made a hybrid microgrid model that has battery storage. When the sun is shining, the solar system generates electricity by absorbing radiation from the sun. When the sun light is available, the battery will be charged and when the sun light isn't available , the battery will provide power to the grid.

## 1.2 Present sources of Electricity Generation

Since the introduction of electricity, many diverse methods of producing electricity have evolved. Some of them are as follows:

### 1.2.1 Thermal Energy

Thermal Energy is the most conventional source of electric power. Thermal power plants is also referred to as coal thermal power plants and steam turbine power plant. A coal thermal power plant mainly consists of alternator runs with help of a steam turbine. The steam is obtained from high-pressure boilers. The **Fig. 1.1** shows the basic thermal power plant schematic diagram.

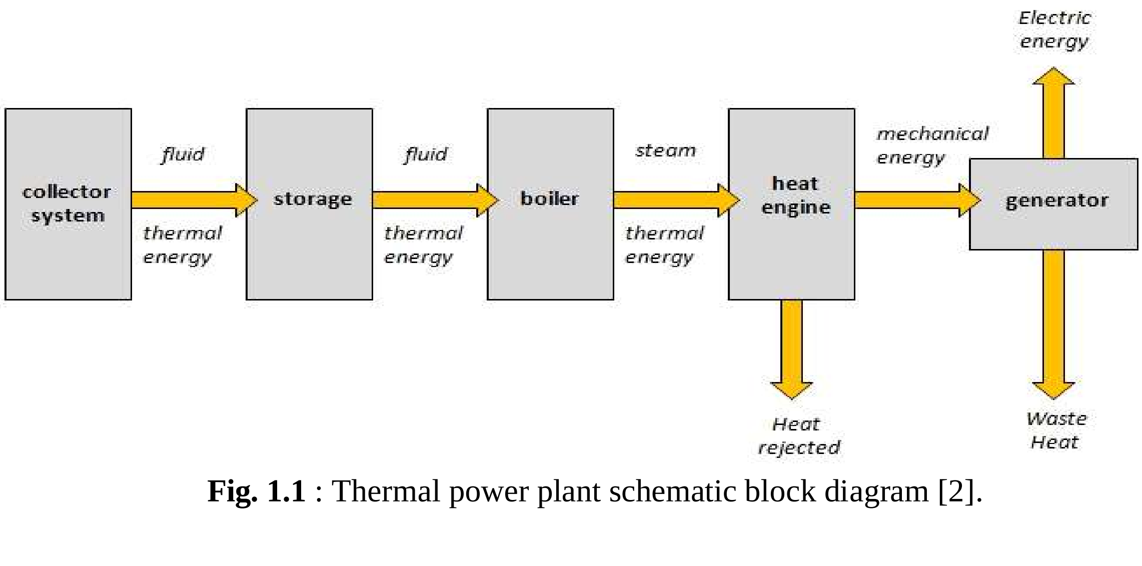


**Fig. 1.1** : Thermal power plant schematic block diagram [2].

### 1.2.2 Other Fossil Fuels

Electricity is generated using fossil fuels such as diesel and natural gas.A fossil fuel power station generates electricity by burning fossil fuels such as coal, natural gas, or petroleum 5% to 16% of the total. To improve thermal efficiency, the coal is used in the boiler in powder form. The **Fig.1.2** shows the combined fossil fuel power plant schematic block diagram.

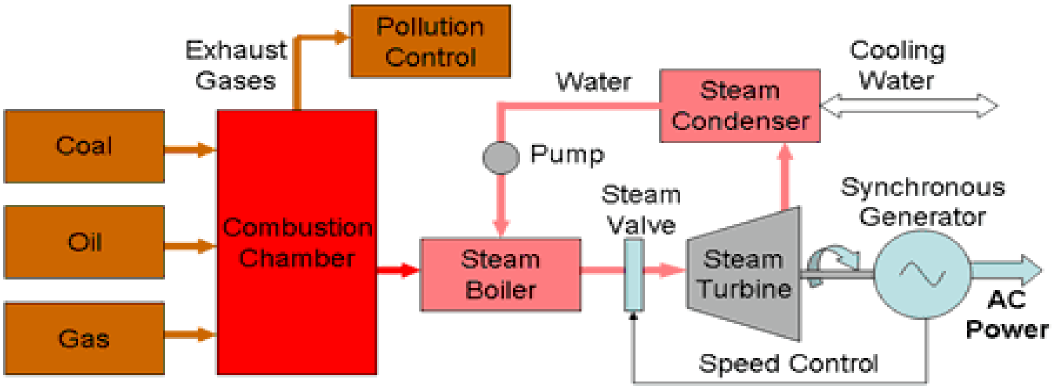


**Fig. 1.2** : Combined Fossil Fuel power plant schematic block diagram [3].

### 1.2.3 Nuclear Energy

Nuclear energy is the use of nuclear reactions to produce heat, which is then used in steam turbines to generate electricity in a nuclear power plant. The definition includes nuclear fission, nuclear decay, and nuclear fusion. The vast majority of nuclear energy in direct service to humanity is currently produced by nuclear fission of elements in the periodic table's actinide series, with the remainder produced by nuclear decay processes, primarily in the form of geothermal energy and radioisotope thermoelectric generators in niche uses. Fission is the process by which nuclear energy is produced by splitting uranium atoms. This generates heat, which is then used to generate steam, which is then used to generate electricity by a turbine generator. The **Fig. 1.3** shows the nuclearr power plant schematic block diagram.

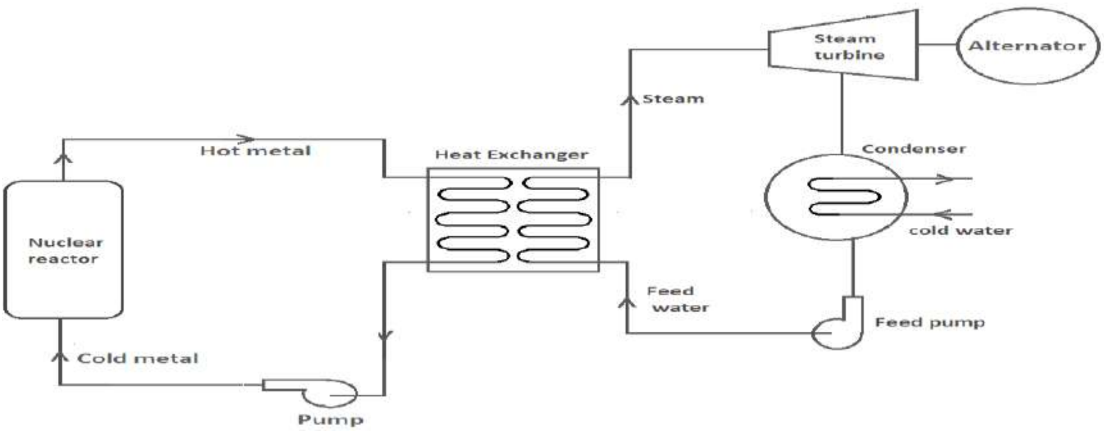


**Fig. 1.3** : Nuclear power plant schematic block diagram [4].

### 1.2.4 Hydro Energy

The energy of falling or fast running water that can be harnessed for useful purposes is known as hydro energy. Hydropower from various types of watermills has been used as a renewable energy source for irrigation and the operation of various mechanical devices, including gristmills, sawmills, textile mills, trip hammers, dock cranes, domestic lifts, and ore mills, since ancient times. Electricity is typically generated using hydro energy, which harnesses the potential energy of water stored at a certain height above ground. This potential energy is used to turn the turbines at the bottom, generating electricity. The **Fig. 1.4** shows the Hydro power plant schematic block diagram.

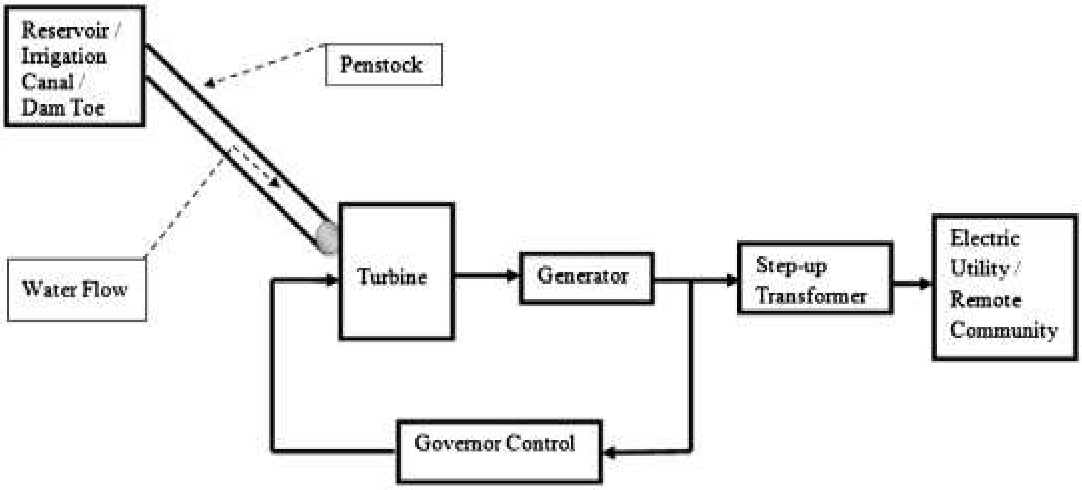


**Fig. 1.4** : Hydro power plant schematic block diagram [5].

### 1.2.5 Wave Energy

Wave Energy comes from the wind and can be used for things like electricity, water desalination, or the pumping of water (into reservoirs). Waves are made by the wind moving over the surface of the sea. There is an energy transfer from the wind to the waves as long as the waves move slower than the wind speed that is just above the waves There are two things that make waves grow: air pressure differences between the upwind and the lee side of a wave crest as well as friction caused by the wind on the water surface. It is called a "wave energy converter" when a machine can use waves to get energy from them (WEC). Wave power is different from the flow of tidal power and the steady gyre of the ocean currents. Wave-power generation is not currently a widely employed commercial technology, although there have been attempts to use it since at least 1890. The **Fig. 1.5** shows the Wave power plant schematic block diagram.

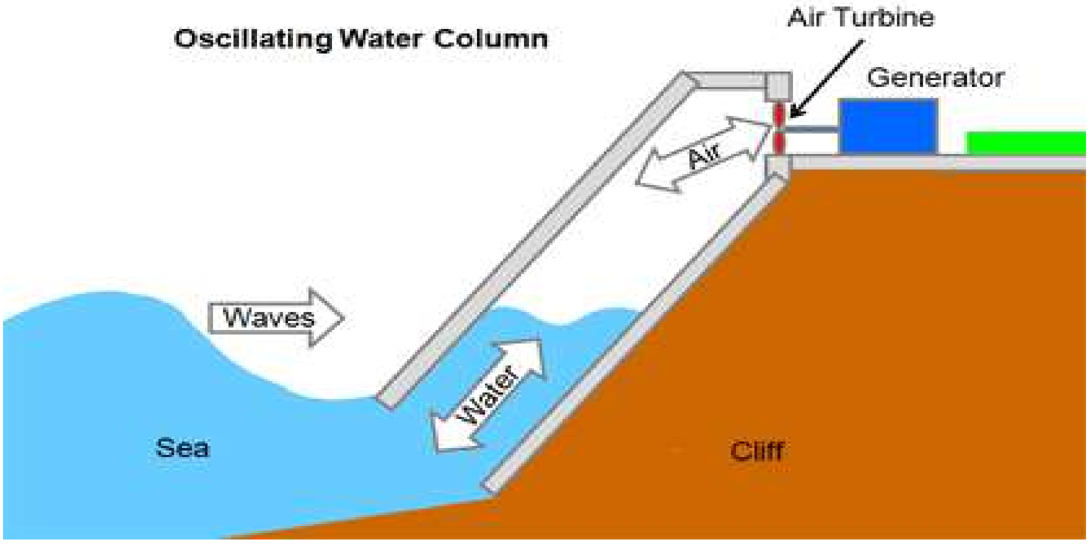


**Fig. 1.5** : Wave power plant schematic block diagram [6].

### 1.2.6 Tidal Energy

Tidal energy is a type of hydropower that turns the energy from the tides into useful forms of power, mostly electricity. Tidal power comes from the Earth's oceanic tides, and it is used to move the Earth. Tidal forces are changes in the gravitational attraction of celestial bodies that happen at regular intervals. These forces make the world's oceans move in the same way, Because of the strong attraction to the oceans, a bulge in the water level is formed, which causes the sea level to rise for a short time. There is a tide when the sea level rises, and water from the middle of the ocean moves toward the shore. This happens every time because the moon's orbit around the earth is always the same. The size and character of this movement are based on how the Moon and Sun move around the Earth, how the Earth rotates, and the geography of the sea floor and coastlines in the area. This is the only way to get energy from the Earth–Moon system and the Earth–Sun system. The **Fig. 1.6** shows the Tidal power plant schematic block diagram . Tidal power is the only way to get energy from these systems. When it comes to renewable energy sources, tidal power has traditionally been one of the more expensive and hard to find. This has limited its total availability.

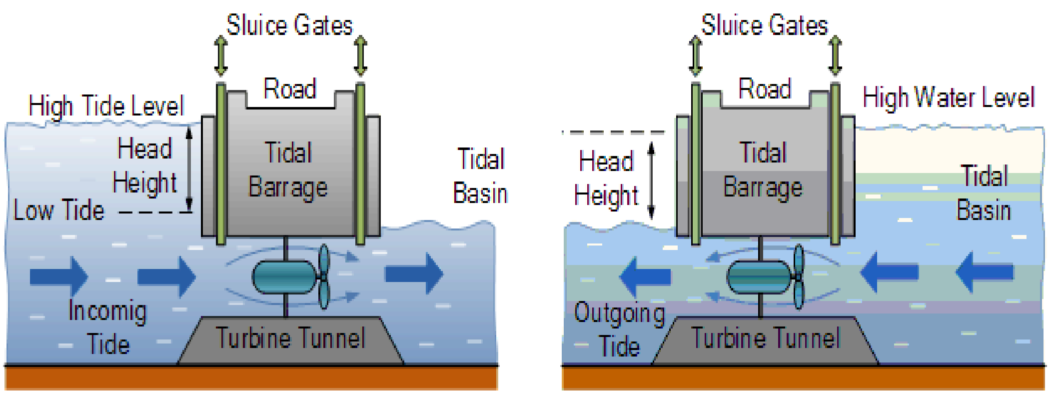


**Fig. 1.6** : Tidal power plant schematic block diagram [7].

### 1.2.7 Ocean Energy

Ocean thermal energy conversion (OTEC) is a way to use the temperature difference between the cooler deep seawater and the warmer shallow or surface seawater to run a heat engine and do useful work, usually in the form of electricity. This process is called ocean thermal energy conversion. If a system is closed-cycle or open-cycle, it is possible for it to be used again. When you use closed-cycle OTEC, you use working fluids that are usually thought of as refrigerants like ammonia or R-134a. These fluids have low boiling points, so they can be used to run the system's generator and make electricity. The most common heat cycle for OTEC so far has been the Rankine cycle, which uses a low-pressure turbine to move the heat around. The **Fig. 1.7** shows the Ocean power plant schematic block diagram.

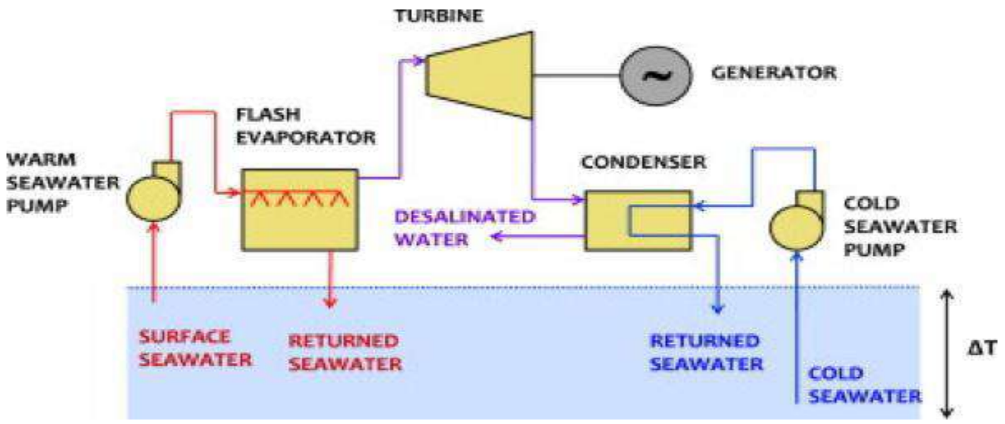


**Fig. 1.7** : Ocean power plant schematic block diagram [8].

### 1.2.8 Solar Energy

A wide range of ever-evolving technologies, including solar heating, photovoltaic, solar thermal, solar architecture, molten salt power plants and artificial photosynthesis, are used to harvest solar energy from the Sun. This renewable energy source is categorized as either passive or active based on how it captures, distributes, and converts solar energy into solar power. Photovoltaic systems, solar concentrators, and solar water heaters are all examples of active solar energy harvesting methods. Buildings can be made more energy efficient by using passive solar methods, such as orienting them toward the sun, using materials with high thermal mass or light scattering qualities, and creating open, airy interiors. The **Fig. 1.8** shows the Solar power plant schematic block diagram.

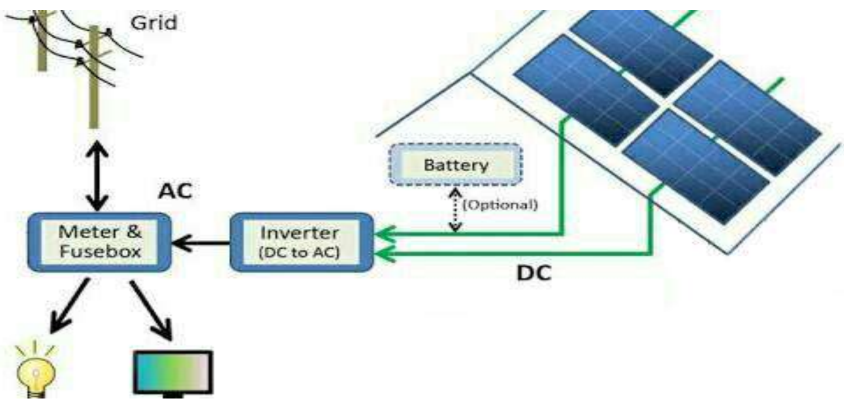


**Fig. 1.8** : Solar power plant schematic block diagram [9].

### 1.2.9 Wind Energy

Wind energy is used to power wind turbines, which in turn power generators that generate electricity. Wind power, as an alternative to burning fossil fuels, is abundant, renewable, widely distributed, clean, emits no greenhouse gases while in operation, consumes no water, and occupies little land. The environmental consequences are far less severe than those of nonrenewable energy sources. Wind farms are made up of many individual wind turbines that are linked to an electric power transmission network. Onshore wind is a low-cost energy source that is competitive with, and in many cases cheaper than, coal or gas plants. Offshore wind is more consistent and powerful than on land, and offshore farms have a lower visual impact, but construction and maintenance costs are significantly higher. Small onshore wind farms can either feed some energy into the grid or provide electricity to remote off-grid locations. The **Fig. 1.9** shows the wind power plant schematic block diagram .Wind power produces variable power that is very consistent from year to year but varies significantly over shorter time scales. As a result, it is used in conjunction with other electric power sources to provide a consistent supply.

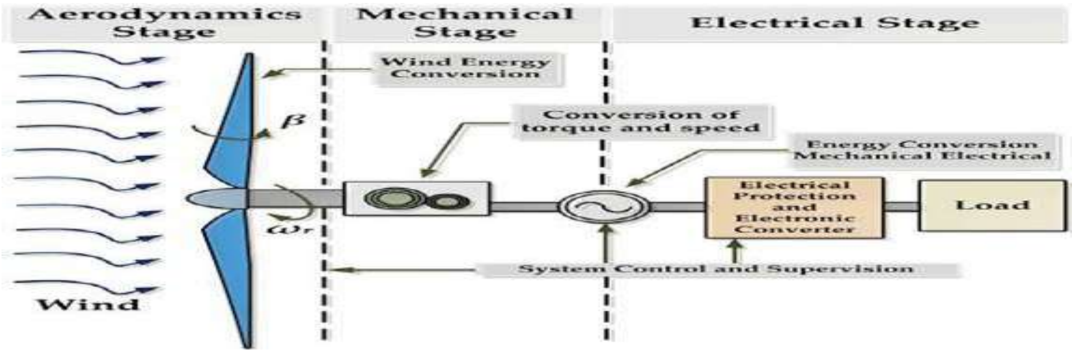


**Fig. 1.9** : Wind power plant schematic block diagram [10].

### 1.2.10 Nuclear Power Plants

Nuclear power plants have one environmental issue that no other type of power plant does. A nuclear power plant accident could result in the release of large amounts of radioactive particles, potentially resulting in a direct loss of life and rendering a large land area immediately surrounding the plant uninhabitable. The most significant ongoing environmental impact is the disposal of high-level nuclear waste contained in spent fuel rods, which must be safely stored for thousands of years. Because there are currently no sites in the United States that accept high-level nuclear waste, utilities are generally storing the waste in above-ground casks at plant sites [11]. The **Fig. 1.10** shows the Nuclear power plant schematic block diagram.

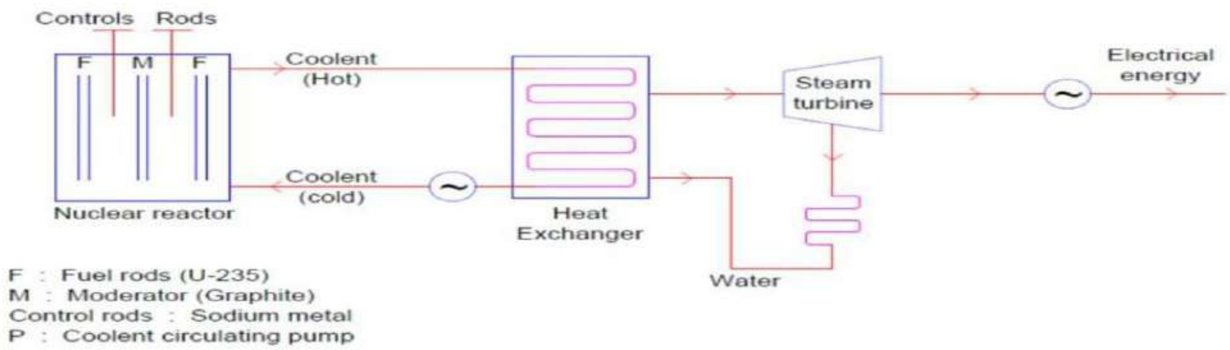


**Fig. 1.10** : Nuclear power plant schematic block diagram [12].

### 1.3 Problem statement and proposed solution

#### 1.3.1 Problems Identified

- For most of the country's economic activity, electricity is the primary source of power . Bangladesh's total installed electricity generation capacity (including captive power) was 20,000 megawatts in 2018 [13]. The consumption of power in Chittagong is over 1,000 MW, although the system only supplies 700 to 750 MW [14]. It's probable that it won't be able to meet the demand for the entire city of Chattogram.
- The maximum power point tracking (MPPT) plays a major role in photovoltaic (PV) power system. Maximum Power Point Tracking, or MPPT, is a feature of charge controllers that is used to extract the maximum available power from a PV module under certain conditions. The maximum power point is the voltage at which a PV module can produce the most power (or peak power voltage). Maximum power is affected by solar radiation, ambient temperature, and the temperature of the solar cell [15] [16]. So we need to control the MPPT of PV.

#### 1.3.2 Proposed Solution

- For decreasing the shortage of power demand we proposed a Hybrid Microgrid model for 37no Halishahar ward of Chattogram City Corporation. Hybrid Microgrid model consists of PV array and Wind turbine with a battery storage.
- To control the MPPT of Photovoltaic Array we use a Fuzzy Logic Controller.

### 1.4 Motivation

Bangladesh power generating depends on 80% on natural gas and other 20% depends on other sources. But the natural gas is limited but Bangladesh’s power demand has been increasing at an average pace of 10% over the last decade. The population growth rate is very high in our country. Day by Day the power demand increases with population. Chattogram is the second populated city in Bangladesh so that the demand is too high and the national grid can’t fill the power demand. For shortage of power or electricity Load shedding occurred and people face many problems. The main motive of this thesis is to provide the needed electrical power for 32no North Mid Halishahar ward of CCC. The output was too good, the PV can produce a significant amount of power from the sunlight and also the wind turbines can produce a significant amount of electrical power by using the velocity of air. The hybrid system is able to produce a large amount of electrical power than former system. The design can be used in any city around the world and hopefully it can be a effective solution towards our power crisis

### 1.5 Objectives

The main objectives of this thesis are:

- To propose a hybrid microgrid model system power using wind turbine and solar cell .
- To propose a hybrid microgrid model to meet the power demand of 37no Halishahar ward of Chattogram City Corporation.
- To control the MPPT of PV using Fuzzy Logic Controller.

### 1.6 Thesis Outlines

In this thesis, we described and discussed about our project in 7 chapters. The outlines of our thesis are as follows:

-  Chapter 1 contains the introduction. In this chapter, introduction of the thesis topic has been discussed.
-  Chapter 2 contains an overview. An overview of wind and solar has been discussed.
-  Chapter 3 contains a literature review. All the previous works related to this thesis has been discussed in this chapter.
-  Chapter 4 contains methodology where the method of developing the Simulink model has been discussed.
-  Chapter 5 contain result and analysis of all output has been discussed.
-  Chapter 6 contains the conclusion and future scope where conclusion and future possible field of the thesis has been discussed.

# Chapter-2

## An overview of wind and solar energy

### 2.1 Wind Energy

Wind energy is a clean and sustainable energy source. It does not pollute the environment and will never run out. Wind energy technology is rapidly evolving, and turbines are getting less expensive and more powerful, lowering the cost of renewable energy. Europe leads the way in this high-tech business.

### 2.2 Wind Energy Technology

Almost all wind turbines are made out of rotor blades that revolve around a horizontal hub. The hub is linked to a gearbox, which is made up of two cogwheels, one bigger and one smaller. The low-speed shaft is a shaft from the turbine that connects to the huge cogwheel. The bigger cogwheel drives the smaller cogwheel. The high-speed shaft connects the generator to a smaller cogwheel. The cogwheels' job is to convert the low speed of the turbine to a greater speed suited for the generator. The gearbox is required to increase the velocity. The speed is slow and the torque is high at the turbine and the feeding axis into the generator has high speed and low torque. Gearboxes in wind power plants are large, heavy, complicated and expensive. The best solution is to avoid gearboxes in the construction of wind power plants, but this is only possible if a permanent magnet induction generator is used. Either DC generator or AC generator can be used in a wind power plant. DC generators have the advantage of being able to operate at varying rotor speed, but now a days it is rare to use direct current generators for high voltage . DC generators are mostly used to charge batteries in tiny wind turbines, however they are not employed in bigger wind turbines. As a result, three phase alternating current generators are employed in wind power facilities.

### 2.3 Wind Turbine Systems:

A wind turbine is a revolving mechanism that transforms wind kinetic energy into mechanical energy. When mechanical energy is employed directly by machinery like as a pump or grinding stones, the machine is commonly referred to as a wind mill. If mechanical energy is converted into electrical energy, the equipment is referred to as a wind generator, wind turbine, wind power unit (WPU), or wind energy converter (WEC). **Fig. 2.1** depicts the basic components of a wind turbine.

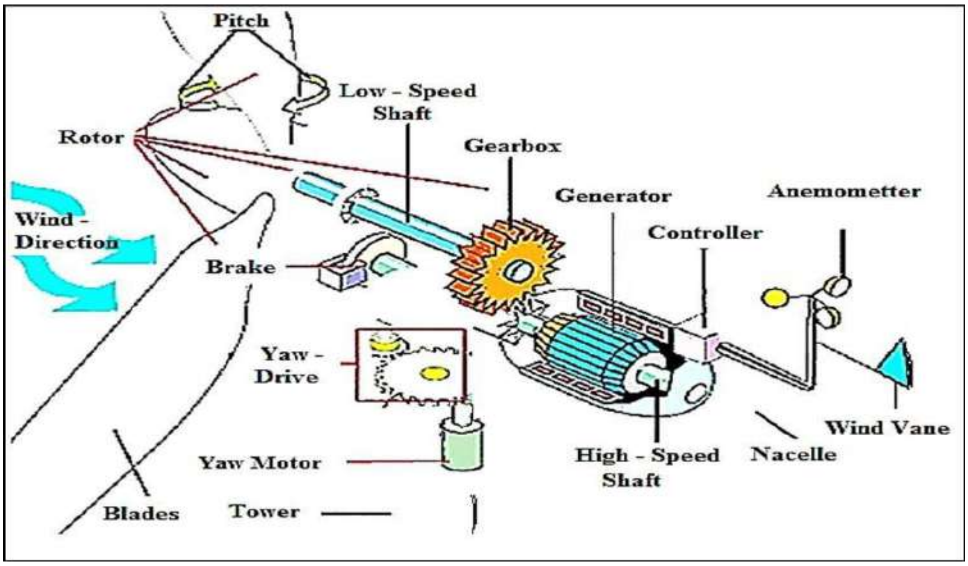


**Fig**. **2.1**: Wind Turbine major Components [17].

**2.4 Components of a typical Wind Turbine:**

A wind turbine typically consists of seven major components. The nacelle, rotor, gearbox, generator, control and protection system, tower, and foundation are the components.

**Nacelle:** Nacelle is a box-like structure located behind the rotor blades

**The nacelle includes:** The outer frame shields the machinery from the elements. The weight of the machinery is supported and distributed by an internal frame. A power train for transferring energy and increasing shaft speeds. A generator is a device that converts mechanical energy into electrical energy. The nacelle on the tower is rotated by a yaw drive.

**Rotor:** Rotor is the elegantly shaped blade that takes wind and converted its kinetic energy into mechanical energy through connected shafts.

**The rotor includes:** In general, the blades are made of glass-reinforced fiber and can be up to 50m long. Carbon fibers are lighter and stronger in larger blades. The blades are linked to a central hub.

The pitch drives are in charge of controlling the blades. The rotor typically has three blades to provide the best balance of high rotation speed, load balancing, and simplicity.

**Generator:** The generator is a device that converts the system's mechanical energy into electrical energy. The generator is usually of the induction variety and runs at a near-fixed speed.

**Control and Protection System:** The wind turbine's computer-based central control panel is typically installed inside the tower (if tubular). The control system monitors gearbox and generator temperature, wind speed, and other parameters. The protection system shields the turbine from the hazardous condition.

**Tower:** The main shaft that connects the rotor to the foundation is known as the tower. It also raises the rotor to a high altitude in the air to capture the strong winds.

**The Tower includes:** Series connections of rolled steel tubes Flanges and bolts hold each section together. A concrete-based stable foundation is required for the turbine assembly..

**Foundation:** The foundation supports the wind turbines make sure that it is well-suited onto the ground. It usually consists of solid concrete.

## 2.5 Types of Wind Turbines:

Wind turbines can rotate about either a horizontal or a vertical axis. Horizontal Wind Turbines are both older and more common. They can also include blades (transparent or not) or be bladeless. Vertical designs produce less power and are less common but are highly efficient and more eco-friendly when compared to Horizontal Wind turbines.

## 2.6 Horizontal Axis Wind Turbines:

The **Fig. 2.2** shows the Horizontal Axis Wind Turbine ,HAWT have the main rotor shaft and electrical generator at the top of a tower and must face the wind. Small turbines are typically guided by a simple wind vane, whereas large turbines are guided by a wind sensor coupled with a servo motor. Most have a gearbox that converts the slow rotation of the blades into a faster rotation suitable for driving an electrical generator.

**Fig. 2.2** : Horizontal Axis Wind Turbine [18].

**2.7 Vertical Axis Wind Turbines:**

Vertical-axis wind turbines (VAWTs) are a type of wind turbine in which the main rotor shaft is oriented transverse to the wind (but not necessarily vertically) and the main components are located at the turbine's base. This configuration places the generator and gearbox close to the ground, making service and repair easier. Because VAWTs do not need to be pointed into the wind, wind-sensing and orientation mechanisms are unnecessary.

The **Fig**. **2.3** shows the Vertical Axis Wind Turbine . A VAWT tipped sideways, with the axis perpendicular to the wind streamlines, works in the same way. This option is referred to as a "transverse axis wind turbine" or a "cross-flow wind turbine" in a broader sense. The tip speed ratios of drag-type VAWTs, such as the rotor, are lower than those of lift-type VAWTs, such as Darrius rotors and cycle turbines. Vertical turbines are characterized by a vertical axis and a wide range of designs, sizes, and colors. It moves in a similar manner to a coin on a table's edge. The primary difference between the VAWT and the HAWT is the position of the blades. Vertical-axis wind turbines are designed to be cost-effective and practical, as well as silent and efficient. They are best employed in home situations, whilst the HAWT works best in commercial settings.

**Fig**. **2.3** : Vertical Axis Wind Turbine [19]

**2.8 What is Solar Energy**

Every day, the sun radiates an enormous amount of energy that is called solar energy. It radiates more energy in one second than the world has used since time began. This energy comes from within the sun itself. Like most starts, the sun is the big ball made up mostly of Hydrogen and Helium gas. The Sun makes energy in its inner core in process called nuclear fusion. The amount of the solar energy an area receives depends on the time of the day, the Season of the year, the cloudless of Sky, and how close you are to earth equator.

**2.9 Working Principle**

If a piece of p-type silicon is placed in intimate contact with a piece of n-type silicon, then a diffusion of electrons occurs from the region of high electron concentration (the n-type side of the junction) into the region of low electron concentration (p-type side of the junction). When the electrons diffuse across the p-n junction, they recombine with the holes on the p-type side. The diffusion of carriers does not happen indefinitely however, because of an electric field which is created by the imbalance of charge immediately either side of the junction which this diffusion creates. The electric field established across the p-n junction creates a diode that promotes current to flow in only one direction across the junction. Electrons may pass from the n-type side into the p-type side, and holes may pass from the p-type side to the n-type side. This region where electrons have diffused across the junction is called the depletion region. The action of the light (shower of photons) falling on the junction is to create electron- hole pairs which move under the influence of this built in field such that the electrons migrate to n-region and the holes migrate to p-region. This charge separation will create an electric field opposite to the electric field created by diffusion. If the number of absorbed photons is enough, these two fields will cancel each other, leading to an open circuit voltage between the n and p regions. If these created electrons and holes are made to flow through an external load, electrical energy will be obtained from the absorbed photon. The DC output from the solar arrays enters an inverter. The inverter turns DC electricity into 120-240 volt AC (alternating current) electricity needed for home appliances. **Fig. 2.4** basic operating principle of a Solar Cell. The AC power enters the utility panel in the house. The electricity is then distributed to appliances or lights in the house.

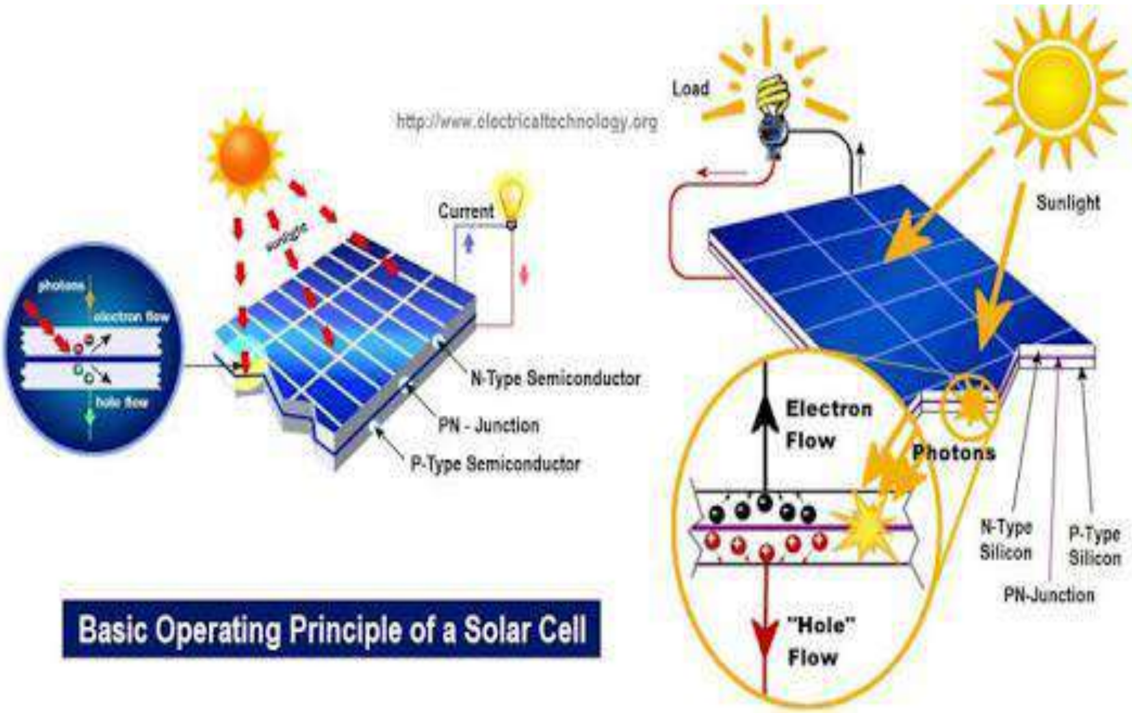


**Fig**. **2.4** : Basic operating principle of a Solar Cell [20].

### 2.10 Characteristics of a Solar cell

A good photo voltaic material should have a large absorption coefficient at low temperature and optimum value of energy gap. If the photon energy is equal to (or) greater than the band gap leads to a large intrinsic carrier concentration and the possibility of photon absorption is less. The photon can be absorbed by the silicon, can generate heat if the photon energy is higher than the silicon band gap value. The construction of a solar cell is difficult because of the fact that one of the crystal (usually p-type) has to be in the form of a single crystal with a controlled impurity. The thickness of p layer is very small when we compare with n-layer to avoid recombination of charge carriers.

#### 2.10.1 PV cells, Modules and Arrays

Photovoltaic cells are connected electrically in series and/or parallel circuits to produce higher voltages, currents and power levels. Photovoltaic modules consist of PV cell circuits sealed in an fundamental building block of PV systems. Photovoltaic panels include one or more PV modules assembled as a pre-wired, field-installable unit. A photovoltaic array is the complete power-generating unit, consisting of any number of PV modules and panels. The performance of PV modules and arrays are generally rated according to their maximum DC power output (watts) under Standard Test Conditions (STC). Standard Test Conditions are defined by a module (cell) operating temperature of 250 C (770F), and incident solar irradiance level of 1000 W/m2 and under Air Mass 1.5 spectral distribution. Since these conditions are not always typical of how PV modules and arrays operate in the field, actual performance is usually 85 to 90 percent of the STC rating. Today's photovoltaic modules are extremely safe and reliable products, with minimal failure rates and projected service lifetimes of 20 to 30 years. Most major manufacturers offer warranties of twenty or more years for maintaining a high percentage of initial rated power output. The **Fig. 2.5** shows the diagram of Solar cell, Module, panel and array

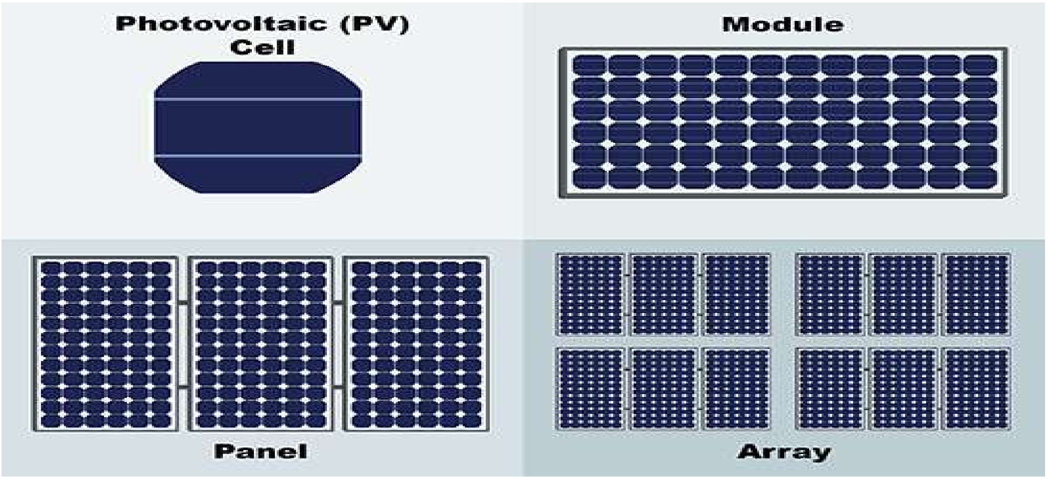


**Fig. 2.5** : Diagram of Solar cell, Module, panel and array [21]

# CHAPTER-3

# LITERATURE REVIEW

## 3.1 Introduction

Wind and solar energy have become increasingly prominent energy conversion options in recent years. This is particularly true for wind energy, which continues to grow at a high rate year after year. A significant percentage of this expansion is accounted for by large-scale commercial power systems. Small-scale renewable energy technologies, on the other hand, are gaining traction as a means of capturing this finite but plentiful resource. A hybrid system that employs both wind and solar energy to diversify supply and make the system's power output more predictable and consistent uses two renewable energy sources. With the depletion of traditional fossil fuels and the substantial pollution caused by industrialization, renewable energy has become an increasingly important alternative to pollution-intensive energy sources in recent years. Ireland gets 93.65% of its energy from fossil fuel resources, with imports accounting for 88 percent of total energy. Ireland boasts one of Europe's most abundant wind resources. The wind energy market grew by over 10% year over year, reaching 45GW of installed capacity. Ireland's solar energy potential is comparable to Germany's, which has successfully employed solar energy to meet large electrical demand. Nevertheless Solar and wind energy, on the other hand, are also intermittent resources with considerable changes across all time scales. Solar or wind energy systems may not be sufficient to power an independent system. Furthermore, energy storage has a considerable financial expense. When the two systems are merged, the resources may compensate for one another, resulting in a more consistent and continuous power output. This chapter has looked into Several works that are similar to simulations of power generation.

## 3.2 Review of Previous Works

Few of the previous work based on the designing and simulating hybrid power plants has described below.

### 3.2.1 Performance Modelling Of a Small-Scale Wind and Solar Energy Hybrid System [22]

**Fig. 3.1** depicts the suggested solar energy subsystem model. The solar irradiation levels, the air temperature, air, and the voltage, V0 are the PV panel's inputs. The irradiation amount is adjusted between 250 and 1000W/m2. Because the temperature coefficient of the PV panel is quite minimal, the temperature is assumed to be constant at 25°C. The boost converter feeds back the voltage. The photovoltaic current, Io, is the PV panel's output. The load resistance must be equivalent to the PV panel's internal resistance in order for the PV panel to produce its maximum power output. The internal resistance of the PV panel, on the other hand, changes over time as it is affected by many factors. the temperature of the environment and the sun irradiation As a result, determining the optimal load is challenging.

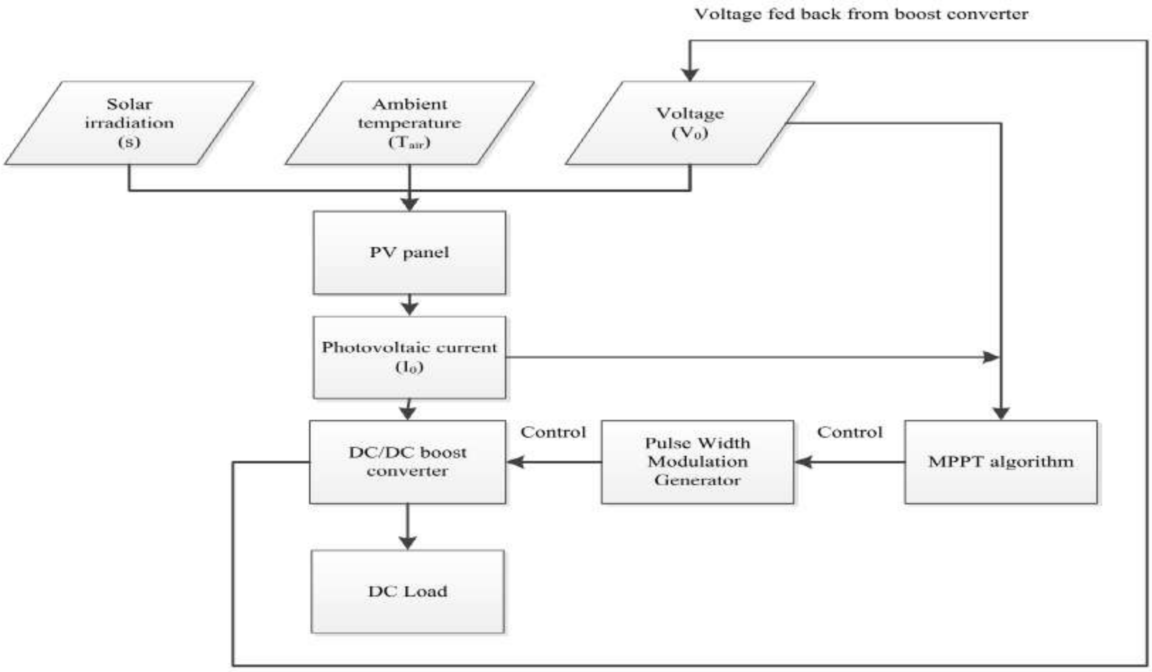


**Fig. 3.1** Modelling Of a Small-Scale Wind and Solar Energy Hybrid System [22]

Adding a DC/DC boost converter between the PV panel and the DC load and altering the duty cycle of the boost converter can vary the equivalent load. As a result, the PV panel's MPPT procedure can be completed. A control block was established in the system function to run the MPPT algorithm in order to modify the equivalent load. This algorithm uses the PV panel's voltage and current to regulate the duty cycle of the Pulse Width Modulation (PWM) generator, which generates a pulse with a width proportionate to the duty cycle. The boost converter's Insulated Gate Bipolar Transistor (IGBT) gate can be controlled by the output pulse, so that the boost converter's equivalent load resistance may be adjusted and the PV panel's maximum power output can be obtained The angular velocity,, the radius of the turbine, R, the pitch angle,, and the wind velocity, V are the model inputs for the wind turbine. Because the wind turbine used has a fixed pitch, the value of is fixed. The wind speed varies from 5 to 8 meters per second. Power and torque are the wind turbine model's outputs. The Permanent Magnet Synchronous Machine (PMSM) then takes the torque value and outputs three-phase AC current and the rotor's rotational speed, which is then supplied back to the wind turbine block's input. The three-phase AC current is then rectified to DC using the universal bridge rectifier.

The rest of this subsystem is comparable to the one for solar energy. In order to change the equivalent load resistance, a buck converter is also connected to the rectifier. The MPPT algorithm block takes the wind turbine's angular velocity and power and adjusts the duty cycle of the PWM generator, which alters the buck converter's equivalent load resistance. As a result, the wind turbine's maximum power output can be obtained.

### 3.2.2 A Management power flow for DC Microgrid with Solar and Wind Energy Sources [23]

The authors propose a DC Microgrid system that includes a solar PV array, a wind energy conversion system, a battery bank, and power converters for interfacing with the DC bus in this proposed work. The block diagram of the DC Microgrid under consideration is shown in **Fig. 3.2**. A 700 W PV array with a 500 W wind generator makes up the DC Microgrid. A boost converter connects the PV array to the 48 V DC bus. Through a rectifier, the induction generator is connected to the DC bus. The MPPT method is implemented using the Perturb and Observe technique. A charger/discharger circuit is used to connect a 24 V battery to the DC link. The charger circuit's job is to keep the DC link voltage in check. The PI controller is in charge of maintaining the bus voltage. The entire system was built in MATLAB/Simulink and put through its paces under various load scenarios as well as changes in input power. If power from solar or wind systems is unavailable, the microgrid can draw power from the batteries. With voltage, frequency, and power quality, microgrid controls can be configured to serve the region and the grid [24-26]. In the literature, many power flow management methods for grid-connected systems have been documented [27-31].

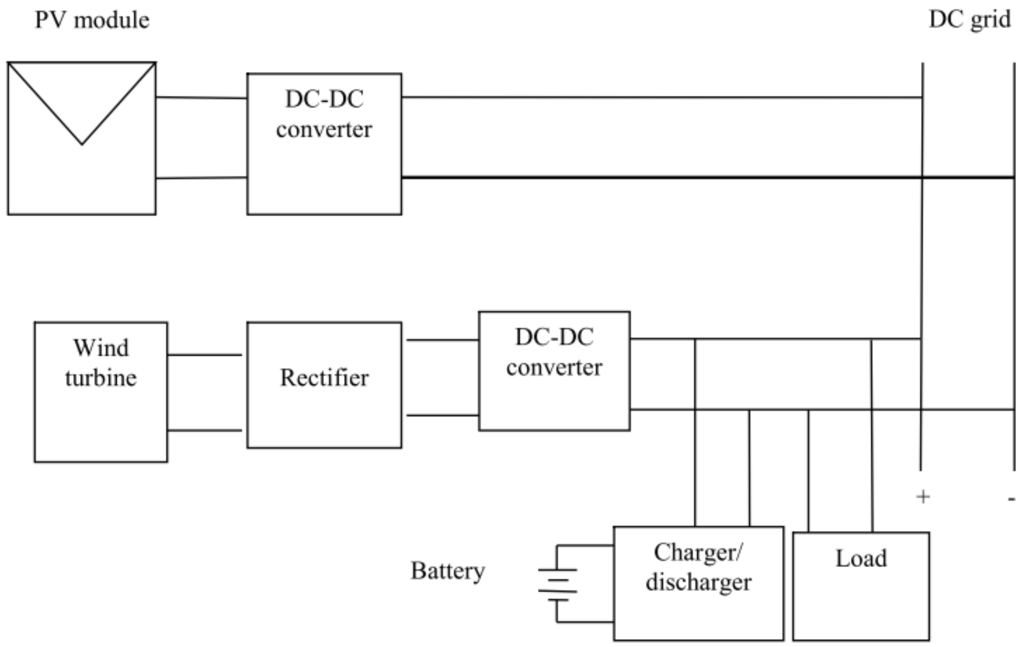


**Fig. 3.2** DC Microgrid with Solar and Wind Energy Sources [23]

It is vital to always run in MPPT mode in order to efficiently utilize the available renewable energy sources. Maintaining the voltage profile in standalone systems is critical, which is accomplished by abandoning the MPPT mode. A battery charger/discharger circuit is utilized in this research to regulate the DC link voltage while maximizing the utilization of renewable energy sources.

The created Management of Power Flow algorithm will determine the mode of operation based on the availability of solar and wind power while taking into account the load demand and battery voltage. This will ensure dependable and uninterrupted power to the load. The solar panel (PPV) generates 630W of power, while the wind turbine (PW) provides roughly 380W. When the load current (IL) drops, indicating that the load demand reduces, the excess energy is used to charge the battery, which is in charging mode. The solar panel (PPV) generates 630W of power, while the wind turbine (PW) provides roughly 380W. When the load current, i.e., the load requirement, rises, the battery switches to discharging mode to make up the difference.

### 3.2.3 Simulation research of a novel wind and solar hybrid power system[32]

**Fig. 3.3** depicts the suggested system topology for the unique wind and solar hybrid generation system. The wind turbine is connected directly to an open-winding permanent magnet machine, with one side of the open-winding connected to a rectifier with a DC side for the load and the other side connected to a three-phase inverter with a DC side connected in parallel to solar panels and storage batteries.

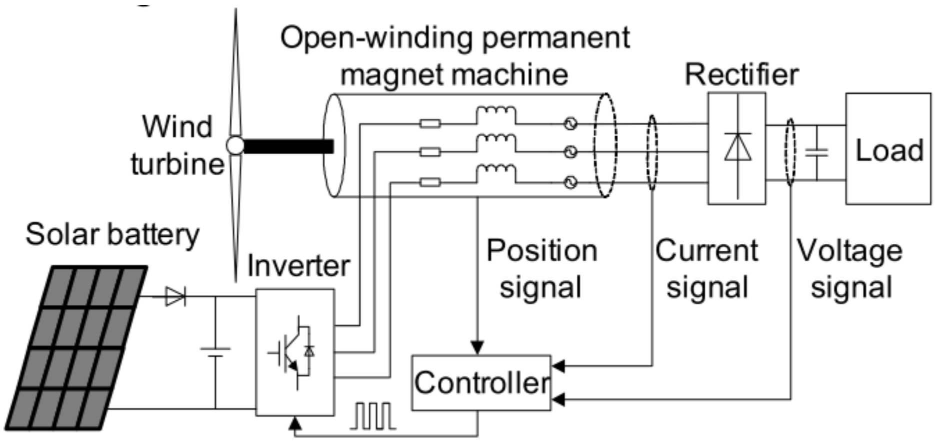


**Fig 3.3** Novel Wind and Solar Hybrid Power System [32]

The load-side DC voltage signal, as well as the machine's voltage and current signals and position signals, are all collected by the controller. At the same time, the inverter is managed for maximum power tracking of the wind turbine and adjustment of the DC load-side output voltage. The inverter is employed in the proposed system to control the DC load-side voltage, as well as the phase currents of the open-winding permanent machine. The load in traditional small and medium-sized wind and solar hybrid power systems is rather stable, and operation time is guaranteed. Solar and wind energy are mutually beneficial. When the wind turbine output power is greater than the load consumption, the excess electricity is stored in a solar battery; when the wind turbine output power is less than the load consumption, the solar battery is the only source of power. The control strategy of the d-axis and q-axis voltage of the inverter is utilized to achieve the voltage regulation of the DC load-side and the MPPT control strategy of the wind turbine[33] [34]. The energy storage of the inductance can be ignored since the phase inductance and resistance of the permanent magnet synchronous machine are modest, so the coordinate transform of the vector control proposed control is utilized in the system strategy. It is possible to establish decoupling control of the component of the excitation current and the torque current of the permanent magnet machine.

# CHAPTER -4

# METHODOLOGY

## 4.1 Introduction

The purpose of this thesis is to proposed a microgrid model that combines both wind electric and solar electric technologies for decrease the shortage of power demand of 32no north mid Halishahar . The system is composed of a wind generator, a solar panel, battery storage and an inverter. The battery storage will be charged full day specifically when sunlight is present and the battery will discharge when the sunlight is absent. After, an inverter will be used to convert DC power to AC power then supply to grid and for domestic load.

## 4.2 Proposed Design of Hybrid microgrid model

The **Fig. 4.1** shows the Proposed Hybrid Microgrid Model with Battery Storage.

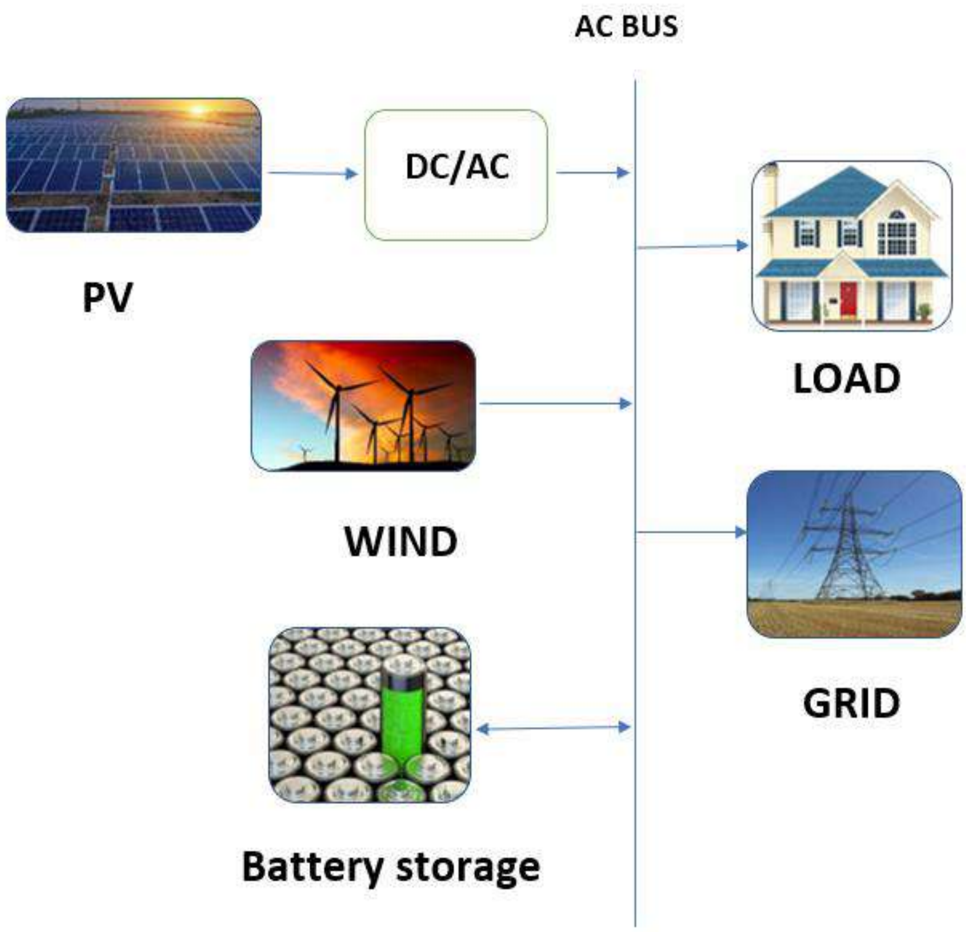


**Fig. 4.1** : Proposed Hybrid Microgrid Model with Battery Storage

### 4.3 Flow Chart of Using Method

The **Fig. 4.2** shows the Flow chart diagram of following method.

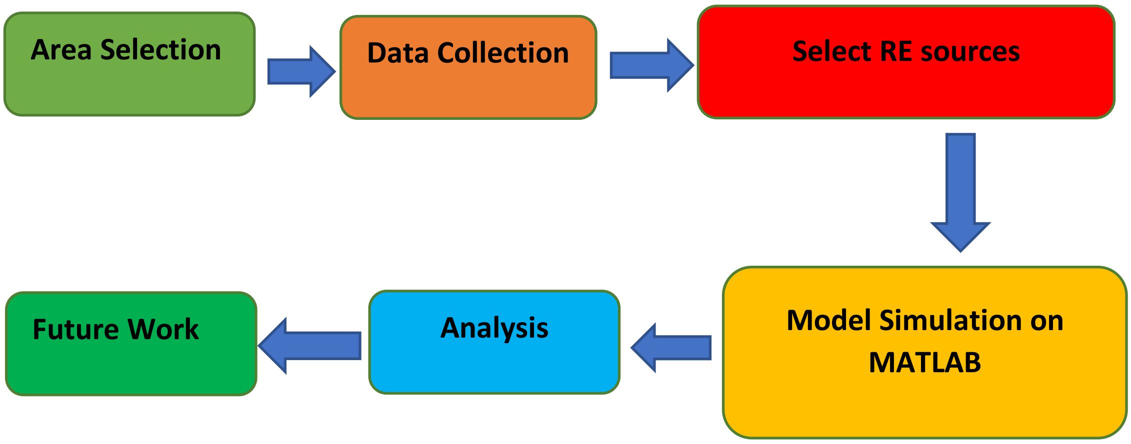


**Fig. 4.2** : Flow chart diagram of following method

#### 4.3.1 Area Selection

Chattogram is large port city on the southeastern coast of Bangladesh . Chattogram city is 2nd most populated city in Bangladesh. The total area of Chittagong City Corporation is 155.4 Sq. km located in between 22°13' and 22°27' north latitudes and in between 91°40' and 91°53' east longitudes. The total Population of Chittagong city corporation 60,00,000 (Approximately) according to data on the Chittagong City Corporation's website 41 . For our proposed idea, we select the 37no north middle Halishahar ward which loacted in between 23.975 latitudes and 90.625 longitudes 90.625 which shown in **Fig. 4.3** . 37no north middle Halishahar ward is a residential area with large population .We see that the area's people facing a lot of problem for Load-Shedding and we all know that Load shedding happens when there is not enough electricity available to meet the demand of all consumers. We select generation side We select Halishahar beach (Latitude: 22.3354757 and Longitude: 91.7620238) side where we will get maximum sunlight and the air with maximum velocity beacuse of sea.


**Fig. 4.3** : Selected Area

### 4.3.2 Data Collection

In **Table 4.1** has the data of population and load demand in five wards of CCC. we see that 37no Halishahar ward has a large population of 69,475 and the load demand is 9.121MW (collected from PGCB) and the national grid cannot fill the load demand. Especially in peak hour the load demand is too high and occurred loadshedding. The load demand in all of these areas varies. It's change time to time. In **Fig. 4.4** shows hourly Load Demands of CCC in five selected wards.

**Table 4.1** : Population (approximate) and Load demand in five ward

| CCC Ward no | Population(approximate) | Load demand (MW) |
|---|---|---|
| 36 | 42352 | 4.814 |
| 37 | 69475 | 9.121 |
| 38 | 87397 | 11.347 |
| 39 | 123397 | 16.071 |
| 40 | 56367 | 6.998 |
| Total | 378988 | 48.351 |

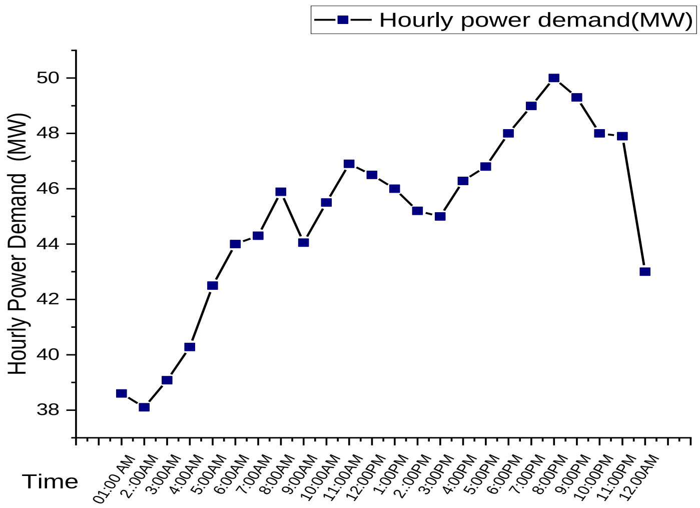


**Fig. 4.4** : Hourly demand vs Hourly Power Curve

### 4.3.3 Selection of suitable Renewable Sources

The distinction between Renewable Energy and Fossil Fuels isn't as difficult as you would assume. Renewable energy is derived from natural resources that can be replenished over the course of a typical human lifespan and comprises the following types of power :

- Solar
- Wind
- Hydro
- Geothermal
- Biomass

Fossil fuels, on the other hand, can take thousands or even millions of years to naturally replenish:

- Natural gas
- Coal
- Oil

If these distinctions sound simple, they aren't always. There are a lot of gray areas. The term "clean power" refers to natural gas because it burns cleaner than coal. People may even think that natural gas is a long-term source of power. Avoid being fooled. In order to make CO2, you burn natural gas. Natural gas comes from fossil fuels and when burned, it makes CO2. In the case of biomass, things get a little more complicated, as well. It can sometimes be more harmful to the environment to burn wood than it is to burn coal. Some scientists, on the other hand, say that wood is a renewable resource because trees can be grown back again.

The old excuse that renewable energy is too pricey is just that: an excuse. It doesn't make sense. To day, renewable energy is just as cheap as energy made by fossil fuels, if not cheaper, and it can eve n be cheaper in some places. Some solar power projects can even make electricity for about half the price of fossil fuels like coal. That's a lot of money that could be saved. The cost of renewable ene rgy is only going to go down over time. Since the start of the Industrial Revolution, the earth's temperature has risen at an alarming rate, which has caused ocean water levels to rise as well. Not only do fossil fuels heat the earth, but they also make bad things like air pollution, which hurts your lungs. Whether or not you believe in climate change, you can still see the effects of fossil fuel combustion all around you in the form of dirty smog, especially in cities with a lot of people. There are some things that emit less CO2 than fossil fuels: renewable energy, on the other hand, usually doesn't. Aside from the time it takes to build them and maintain them, renewables like solar and wind power don't emit any CO2. When you use renewable energy, you can breathe better, stay cooler, and make the world a better place for future generations to live in. When comparing renewable energy to fossil fuels, we have to keep in mind that renewable energy generation is cleaner, easier to keep going for a long time, grows more quickly, and sometimes even costs less than fossil fuels at times.

Considering Halishahar Beach side area we select PV solar and Wind turbine Based Renewable sources for power generation. If we use another source like Incineration, Gasification, Biomass etc. For generating power Each 100KW PV panel contains 64 parallel strings and 5 series conectted modules. Horizontal Axis Wind Turbine is used for wind farm and 15 wind turbine is used for this plant. Every wind turbines height is 25 meter and the blade diameter is 15meter. The PV farm consists of four PV arrays delivering each a maximum of 100 kW at 1000 W/m2 sun irradiance. A single PV array block consist of 64 parallel strings where each string has 5 SunPower SPR-315E modules connected in series. Each PV array is connected to a DC/DC converter (average model). The outputs of the boost converters are connected to a common DC bus of 500 V. Each boost is controlled by individual Maximum Power Point Trackers (MPPT). The MPPTs use the "Perturb and Observe" technique to vary the voltage across the terminals of the PV array in order get the maximum possible power.A three-phase Voltage Source Converter (VSC) converts the 500 V DC to 260 V AC and keeps unity power factor. A three-phase coupling transformer is used to connect the converter to the grid. The grid model consists with feeders and equivalent transmission system.In the PV model the boost and VSC converters are represented by equivalent voltage sources generating the AC voltage averaged over one cycle of the switching frequency. Such a model does not represent harmonics, but the dynamics resulting from control system and power system interaction is preserved. This model allows using much larger time steps (50 us), resulting in a much faster simulation. The **Fig. 4.5** shows the proposed Hybrid Microgrid model for Halishahar area which is 37no ward of CCC.

#### 4.3.4 Model Simulation on MATLAB

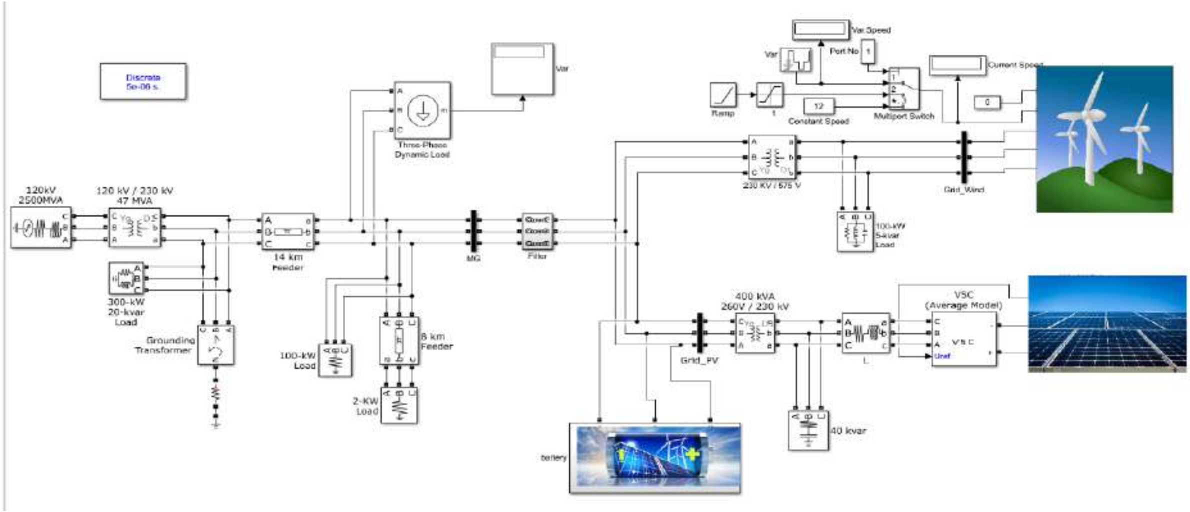

**Fig. 4.5** : Hybrid Microgrid Model on Matlab Simulink

In PV systems, the maximum power point tracking system (MPPT) is critical for increasing solar cell efficiency. Many ways for generating the greatest voltage from PV modules under various weather circumstances have been developed. Using the P & O algorithm, this research suggested an intelligent way for maximum power point tracking. A PV module is coupled to a DC to DC boost converter in the model. The PV system is put to the test under varying levels of sun irradiance and temperature. In **Fig. 4.6** is the 400KW PV array subsystem model .The P&O Method used to measure the Module's voltage, current, and power. This method proposes a fuzzy logic based Mppt controller to boost the voltage Pv module. When the voltage and current across the PV panel change, the suggested technique uses fuzzy logic-based control (FLC) to initiate the control command to the output buck-boost converter. With the help of MATLAB Simulink the FLC-based MPPT controller for the PV module is modeled in **Fig. 4.7.**

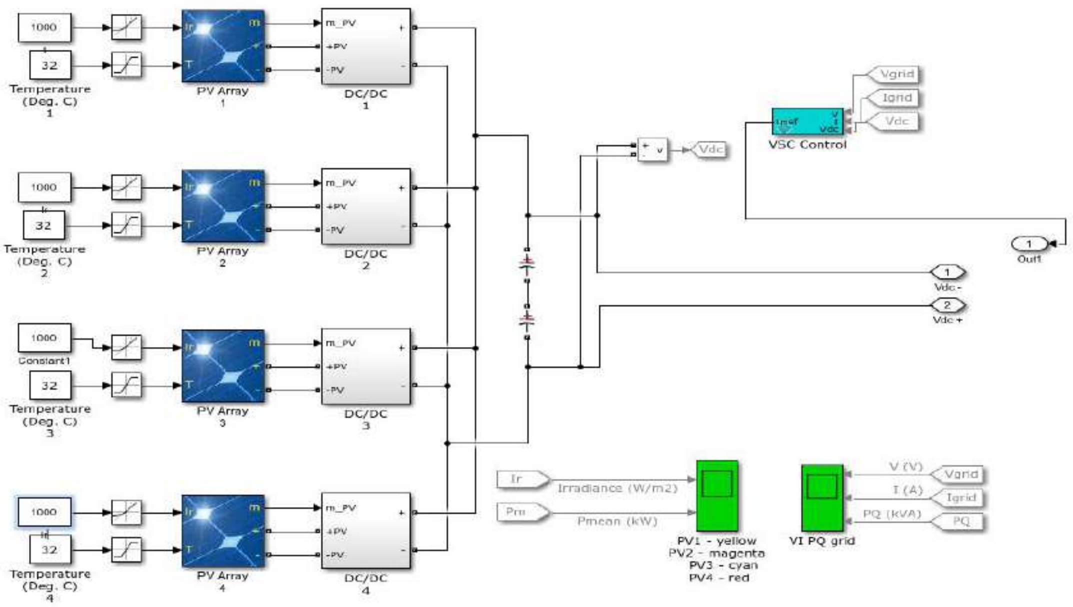


**Fig. 4.6** : 400KW PV Array model in Matlab Simulink

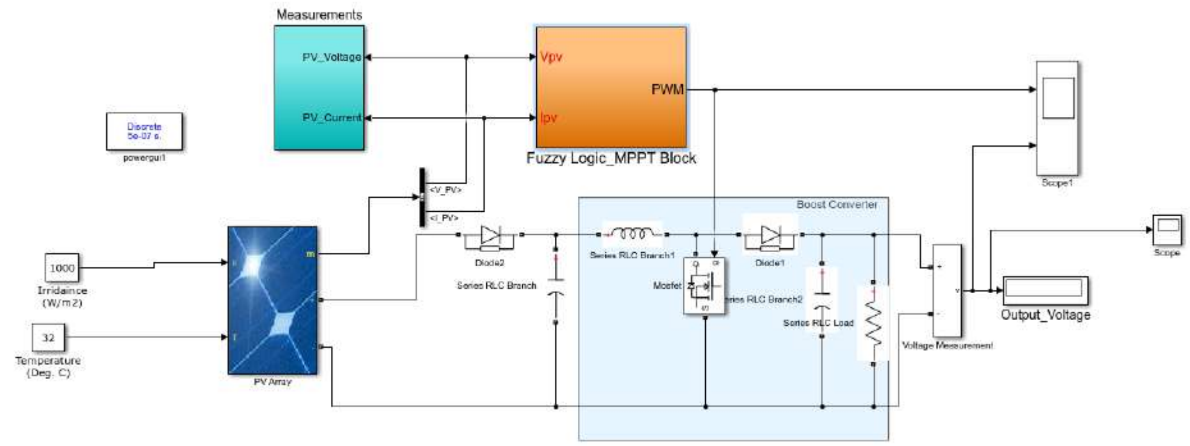


**Fig. 4.7** : Fuzzy Logic based MPPT controller for PV array in Matlab Simulink

Wind energy has many advantages because it does not pollute and is an inexhaustible source of energy. A DFIG wind turbine is designed in Matlab Simulink **Fig. 4.8** and Double Fed Induction Generator (DFIG) is one of the most important generators used for Horizontal Axis Wind Turbine (HAWT) [35]. The DFIG stator is linked directly to the grid, whilst the DFIG rotor is coupled via an electronic converter [35]. In our proposed model we used a battery storage as a backup supply. In **Fig. 4.9** model a simulation of battery storage and it helps us reducing our dependence on the resource because without them, we would not be able to make solar energy during the hours when the sun source isn't available (Night). When PV energy is not generated then the battery storage will supply to the grid otherwise the demand shortage will be shown in night.

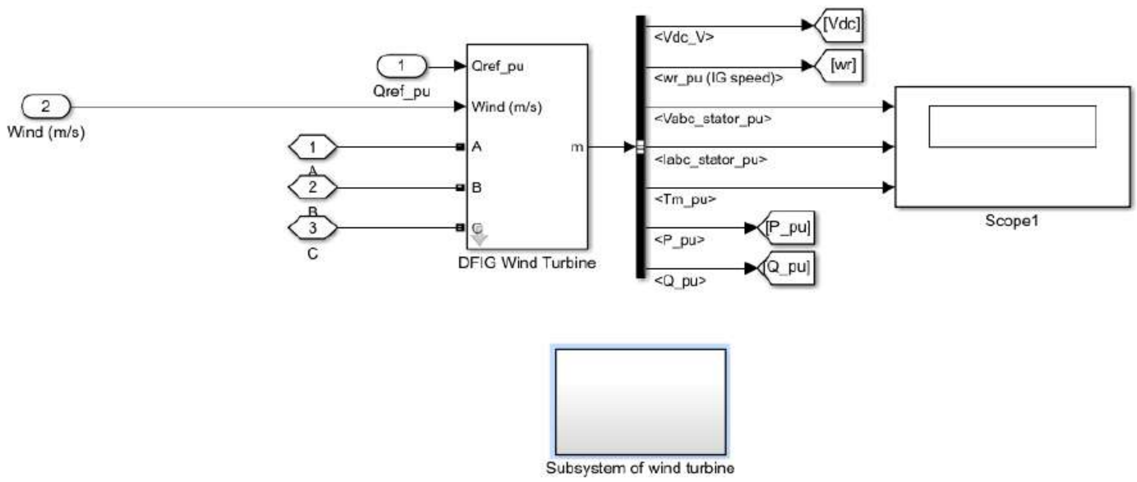


**Fig. 4.8** : DFIG wind Turbine model in Matlab Simulink

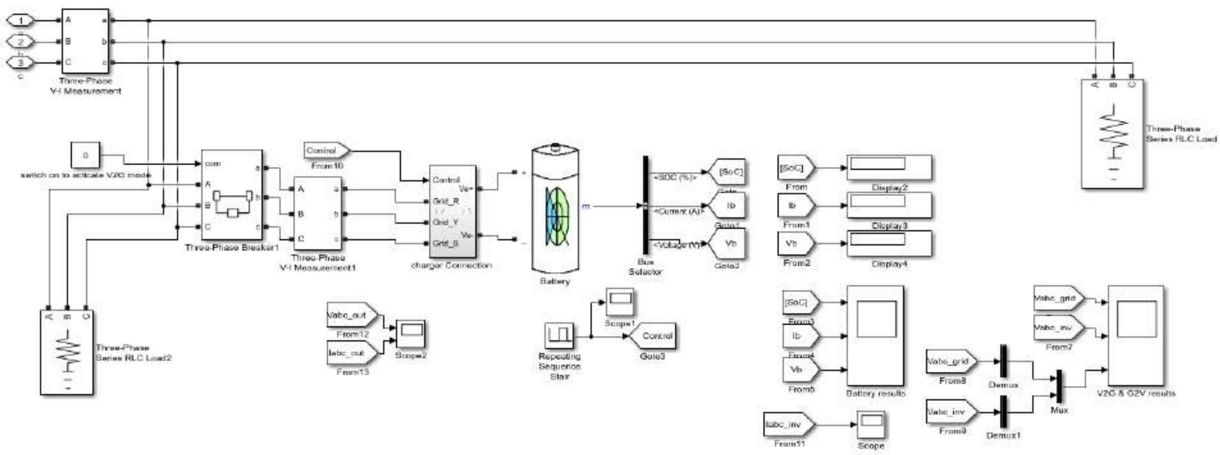

**Fig. 4.9** : Battery storage model in Matlab Simulink

DC–DC (direct current) conversion is one of the most researched and used power electronics functions. To achieve the well-known buck and boost topology, DC–DC elementary conversion modes scale down and up the converter input voltage utilizing power semiconductor devices operated with high-speed control. The buck–boost topology is created by cascading both elementary conversion modes. The resulting converter, with the same number of components, provides a lower or higher output voltage than its input power source, with inverted polarity. Bi-directional battery in **Fig. 4.10**, consist of five main sub system including Connection Control , DC-AC / AC-DC Converter , Buck-Boost Converter, DC-DC converter with battery controller and Battery Switching Control. The ability of a buck–boost converter in **Fig. 4.11** to convert its supply voltage into a higher/lower output makes it a viable option for DC voltage regulation applications ranging from LED lighting [36] to renewable energy sources [37,38], microgrids [39], and battery charging [40,41].

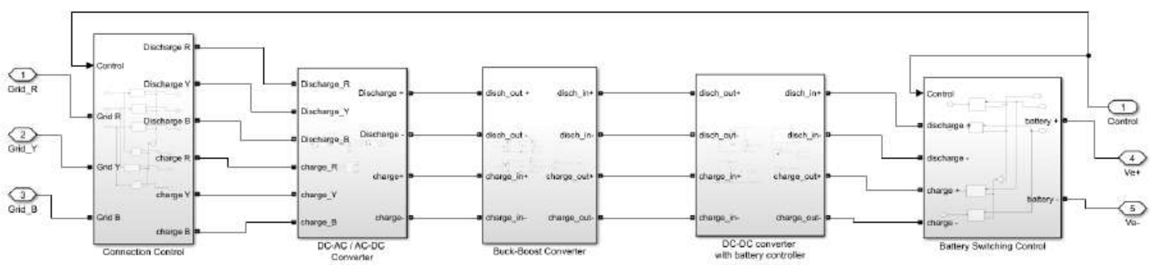


**Fig. 4.10** : Subsystem of Battery

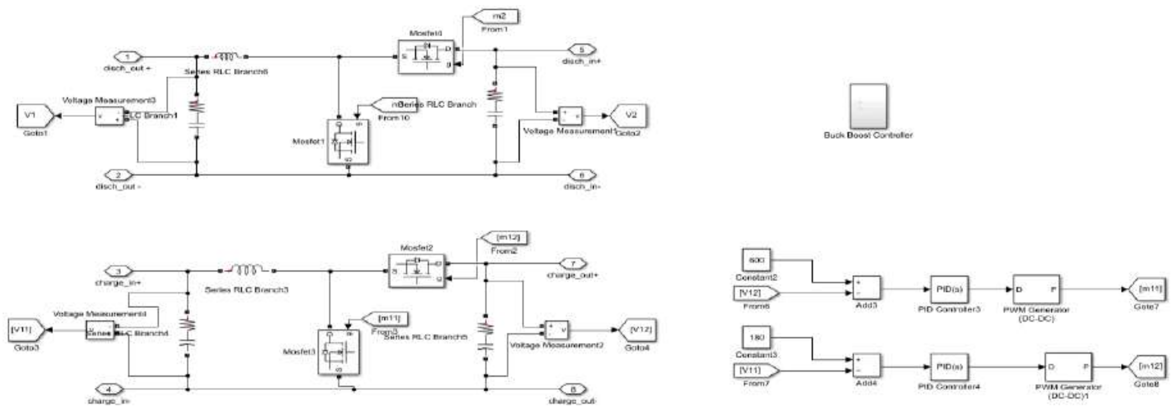

**Fig. 4.11** : Buck-Boost Subsystem of Battery

Several different types of battery chargers have been developed over the years. Many chargers, however, are unsuitable for use due to the charging technique and the safety of the charging process. When the battery pack is connected to the charger, the charger normally charges it automatically, however it continues to charge even when the battery is fully charged. If an explosion occurs during the process, the battery or the user may be damaged. Aside from that, the battery's longevity is critical. A smart charging method can extend the life of your battery. We use a PI controller to control the battery shown in **Fig. 4.12**. By controlling the rise time of the current, overshoot, and error that occur during the charging process, the PI controller can control the output voltage from the charger to meet a desired value. The Proportional (P) action reduces the rise time and error, whereas the Integral (I) action eliminates the error.

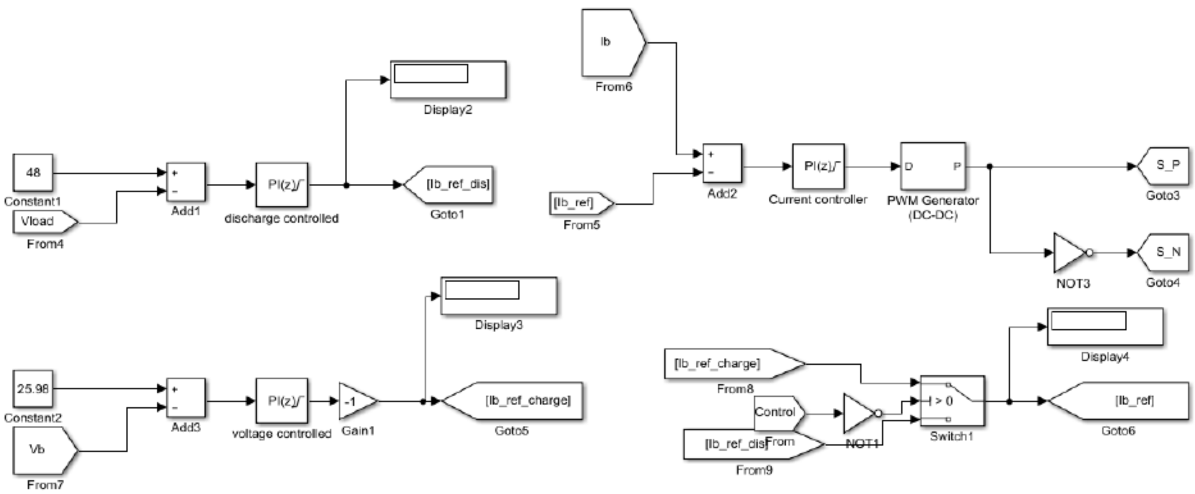


**Fig. 4.12** : Battery Controller Subsystem

# CHAPTER -5

# RESULT AND ANALYSIS

## 5.1 Solar PV Model

In this model, the SunPower SPR-315E-WHT-D PV module is chosen for the proposed model in Matlab simulink. The SunPower SPR-315E-WHT-D under the given parameters of a PV Module is displayed in **Table 5.1** , where **Fig. 5.1** show the I-V and power output of P-V module with different temperature.

**Table 5.1** PV module parameters

| | |
|---|---|
| Maximum Power (Pmax) | 315.072W |
| The voltage at Pmax (Vmp) | 64.6V |
| Current at Pmax (Imp) | 4.9A |
| Open Circuit Voltage (Voc) | 54.7V |
| Short Circuit Current (ISC) | 5.14A |
| Temperature coefficient of Isc | -0.27269 ± 0.113 % |

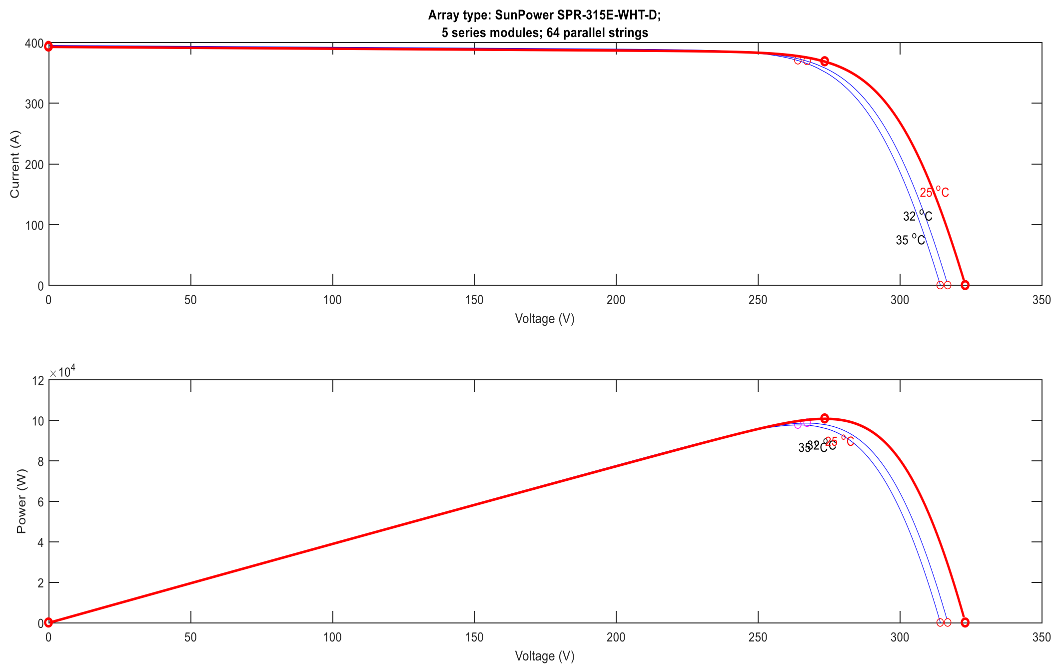


**Fig. 5.1** : V-I and P-V output

The uncertainty is the different weather conditions or can be the radiations or temperature at a different level. The temperature provided to the PV module are at  the different irradiance levels show the **Fig. 5.2** and different temperature range shows in **Fig. 5.3.** In **Fig. 5.4** we see that voltage is varried with time  so that we need to control the voltage of PV.

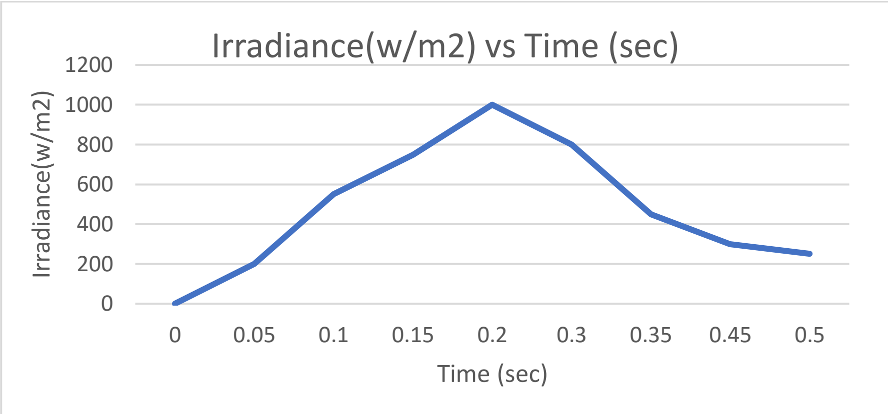


**Fig. 5.2** : Irradiance vs time curve

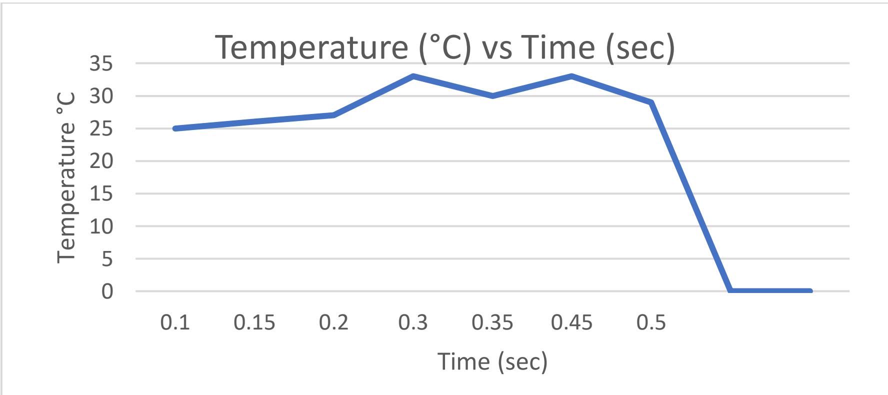


**Fig. 5.3** : Temperature vs time curve

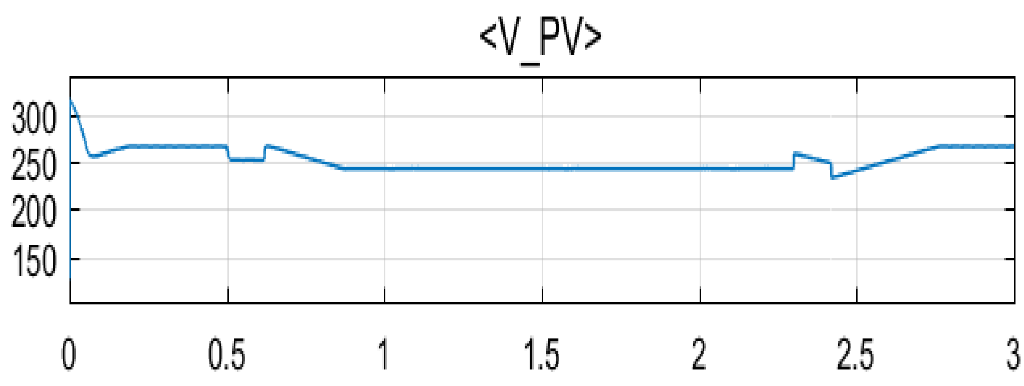


**Fig . 5.4** : Voltage(v) vs time (sec) curve

## 5.2 Fuzzy Logic Based MPPT Controller of PV

Fuzzy control theory is an automatic control theory based on fuzzy set theory, the form of fuzzy language knowledge representing and reasoning, and fuzzy logic rules to simulate the way of thinking and reasoning of human beings. There are several characters of fuzzy control as follows: we can express the related knowledge and experience of manipulators or experts as linguistic variables based on the fuzzy control rules, and then use these rules to control the unknown models or models that are difficult to be established accurately in mathematics of forces [42]. The fuzzy logic controller design involves fuzzification, rule base, inference and defuzzification.

To design this controller MATLAB/Simulink is used, **Fig. 5.5(a)** fuzzy rules for PV and **5.5(b)** is the fuzzy logic designer. In this step, the inputs and outputs are defined for the fuzzy controller. We have defined two inputs We have selected Gaussian membership defuzzification. To design this controller MATLAB/Simulink is used**.** The **Fig. 5.6** shows the membership function of Input Vpv and **Fig. 5.7** shows the input membership function of Ipv. The **Fig. 5.8** shows the membership function for Output Pulse Width Modulation(PWM).

| **Vpv** | **Ipv** | **NB** | **NS** | **Z** | **PS** | **PB** |
|---|---|---|---|---|---|---|
| **NB** | | **PB** | **PS** | **NB** | **NS** | **NS** |
| **NS** | | **PS** | **PS** | **NB** | **NS** | **NS** |
| **Z** | | **NS** | **NS** | **NS** | **PB** | **PB** |
| **PS** | | **NS** | **PB** | **PS** | **NB** | **PB** |
| **PB** | | **NB** | **NB** | **PB** | **PS** | **PB** |

**Fig. 5.5 (a)** : fuzzy rules for PV

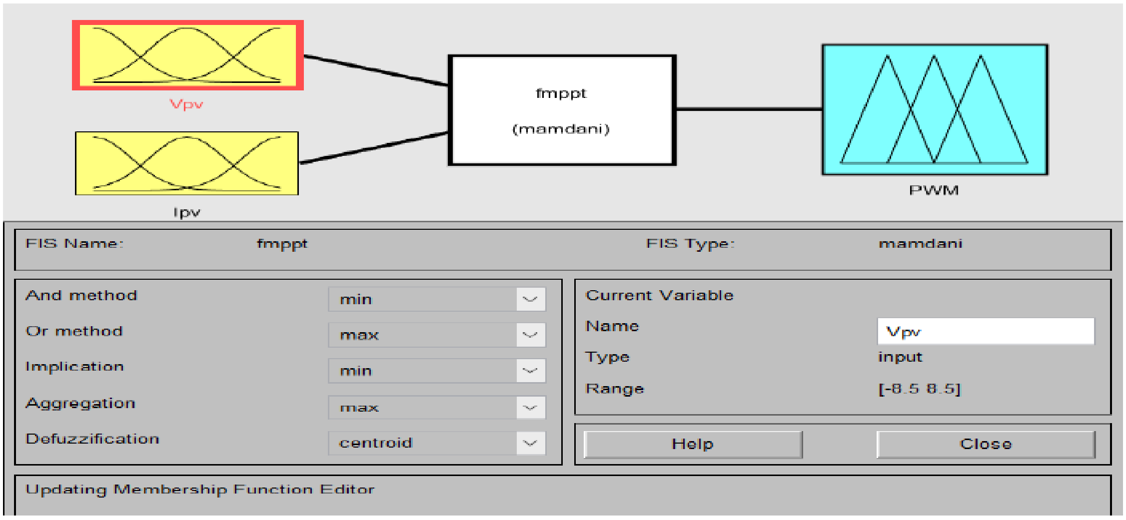


**Fig. 5.5(b)** : Fuzzy Logic Designer

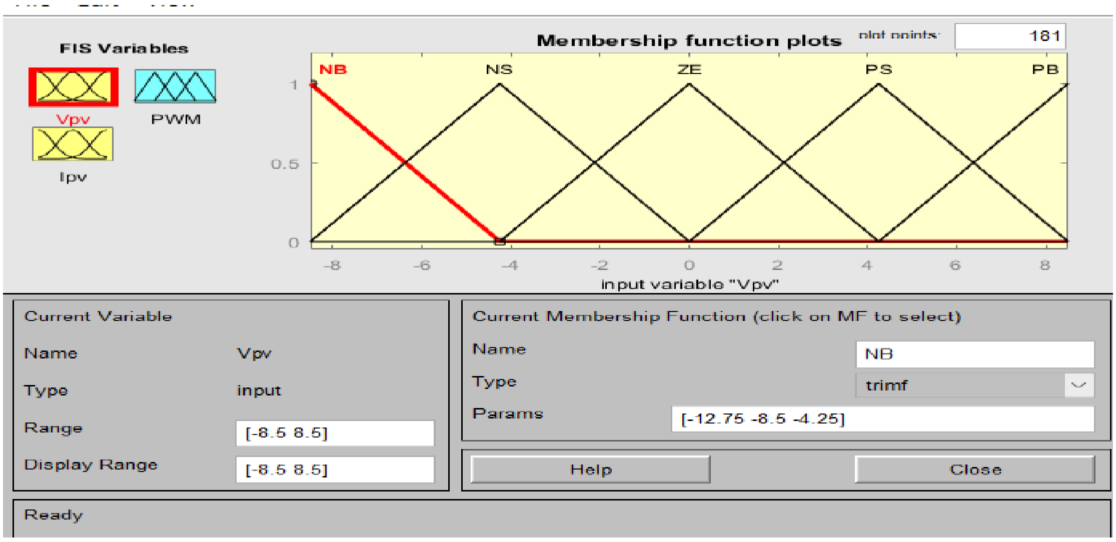


**Fig. 5.6** : membership function of Vpv (Input)

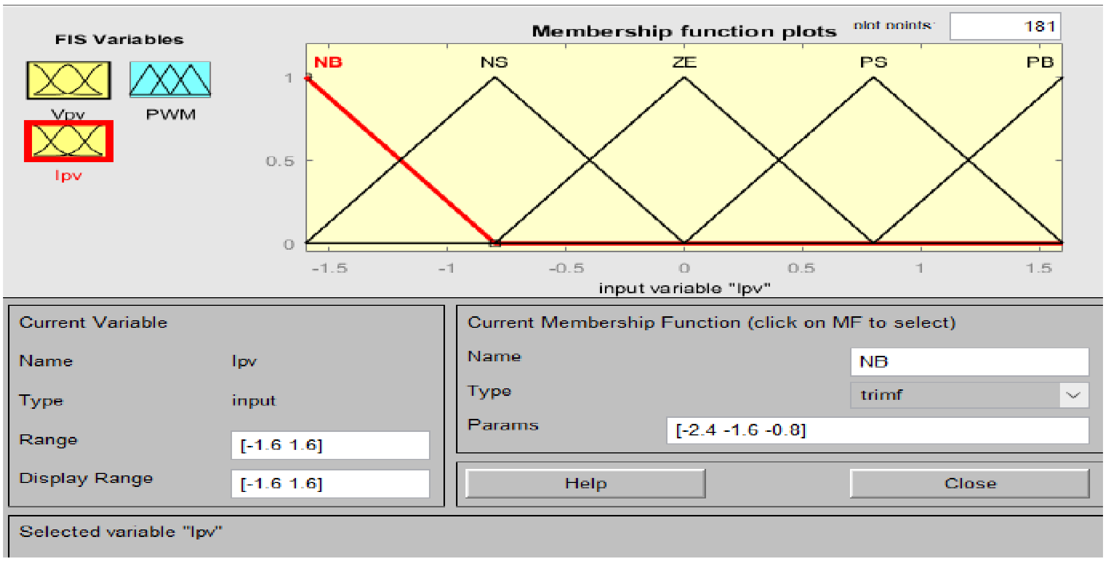


**Fig. 5.7** : membership function of Ipv (Input)

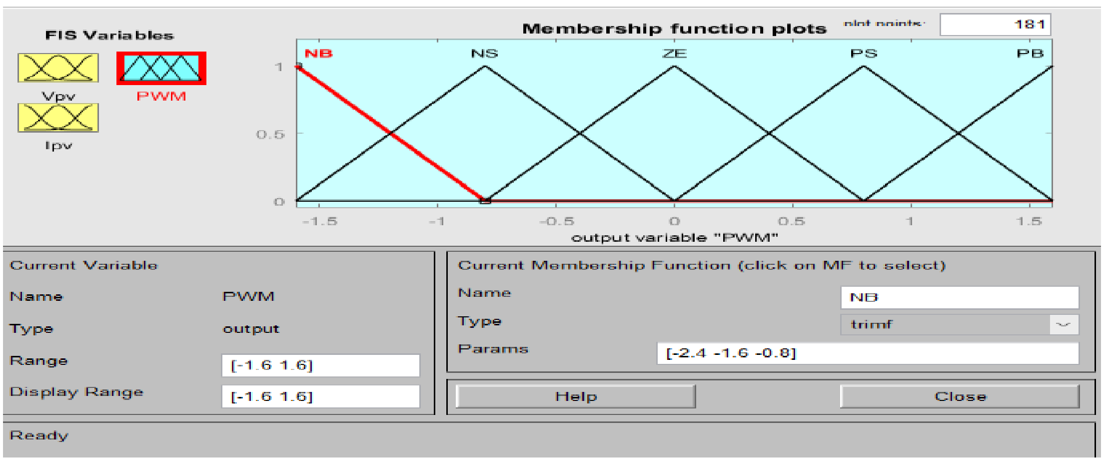


**Fig. 5.8**: membership function of PWM (output)

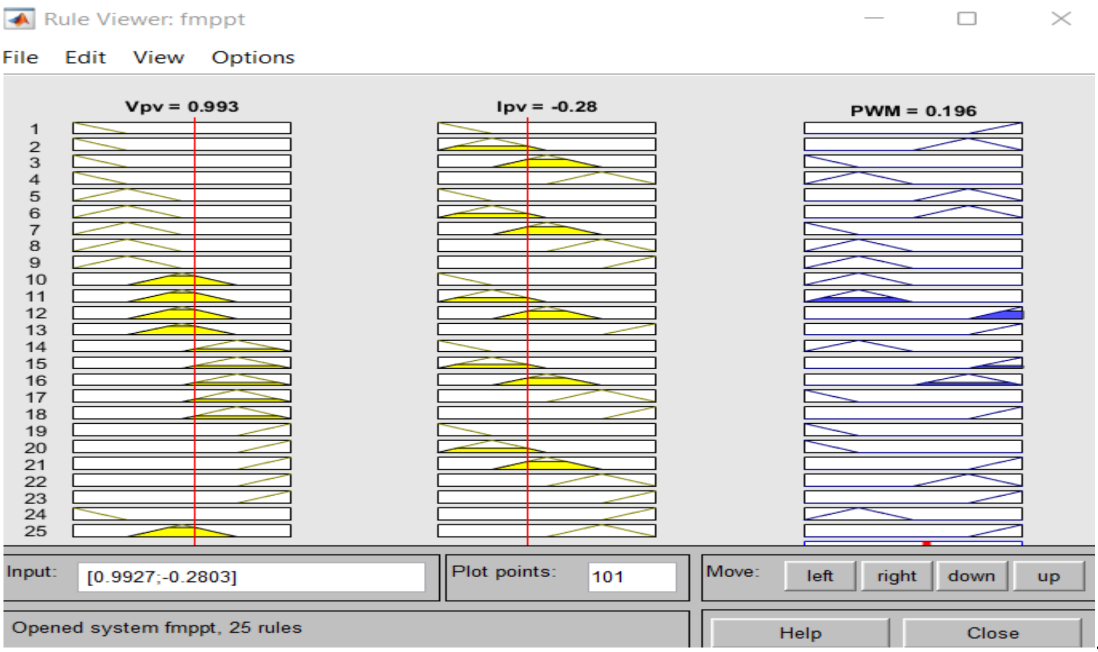


**Fig. 5.9** : Rule viewers

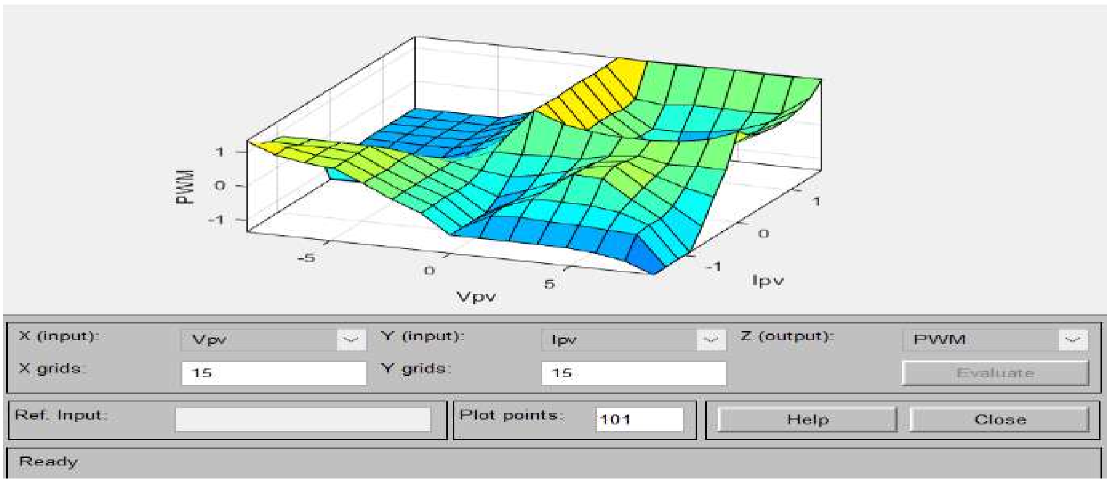


**Fig. 5.10** : Surface viewer

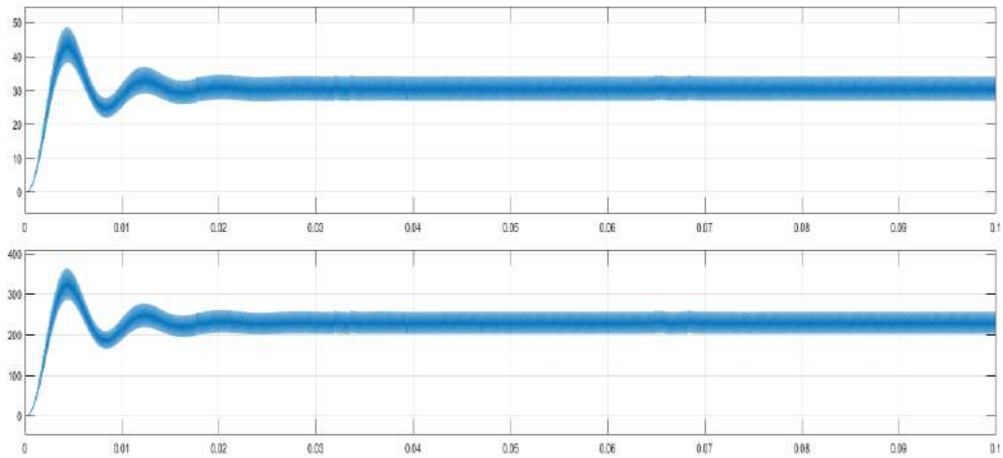

**Fig. 5.11 (a)** : Fuzzy Logic Controller based current and voltage output of PV

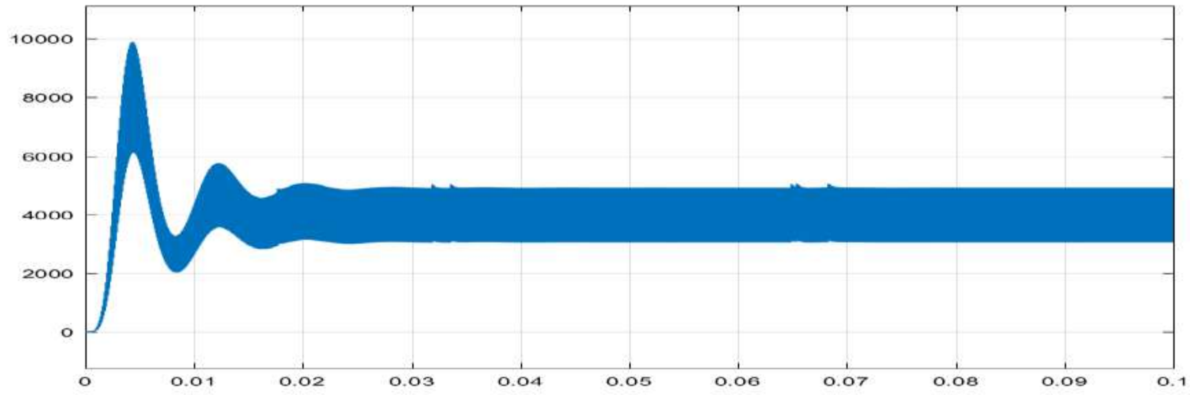


**Fig. 5.11 (b)** : Fuzzy Logic Controller based power output of PV

The **Fig. 5.9** shows the Rule viewers output and **Fig. 5.10** shows the surface viewer output. variable universe of discourse for the system input Vpv range is [-8.5 to +8.5] . Input of Ipv and output PWM range is taken {-1.6 to +1.6]},then divided it into five levels, the linguistic values of the 5 fuzzy sets were taken as {NB, NS, ZO, PS, PM, PB}, that is (Negative Big, Negative Small, Zero , Positive Small, Positive Big). According to the input and output membership functions 25 fuzzy rules for each parameter have been carried out and shown in tables below. After simulating the model we see in **Fig. 5.11(a)** the output current and voltage of MPPT is not varying with time and it's stable so that the voltage doesn't effect in grid , **Fig. 5.11(b)** is the fuzzy logic controller based power output of PV .

### 5.3 Wind Turbine

A frequently used system in wind turbines is the doubly-fed induction generator (DFIG) with the back-to-back converter. Traditional wind turbines have fixed turning speeds, whereas DFIG allows wind turbines to operate at a variable speed range. The back-to-back converter is connected to the DFIG's rotor, and its purpose is to feed the rotor with varying frequency currents in order to achieve the desired rotor speeds. This application note shows how to build a DFIG wind turbine with a back-to-back converter controller. The simulation cases presented in this document cover the dynamic response of DFIG to wind speed changes and during the turbine braking process. [43]. There are a lot of problems when large wind energy farms are put into the power grid. There are voltage spikes, surges, sags, noise, and voltage fluctuation and instability as shown on **Fig. 5.12** which is stator voltage in pu.

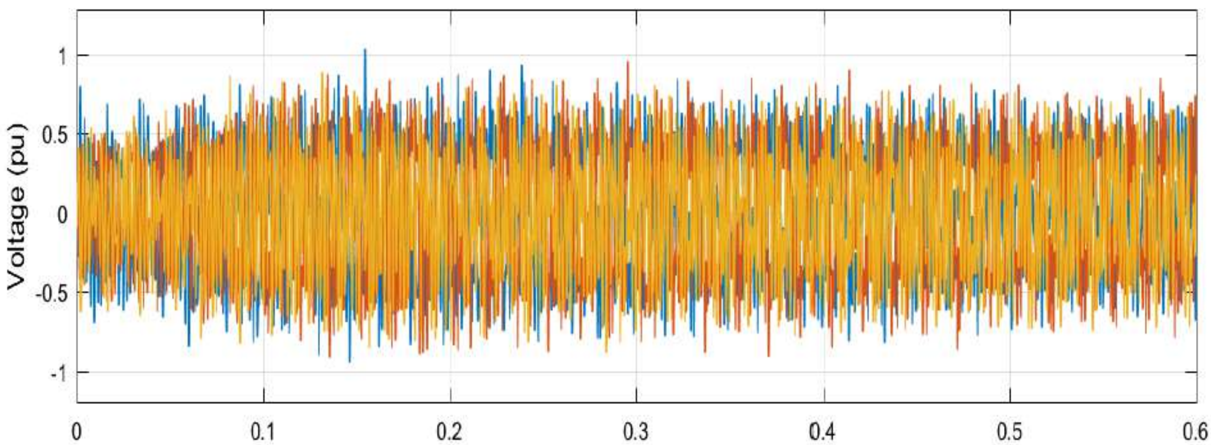


**Fig. 5.12** : WT voltage vs time curve

### 5.4 Battery Storage

Among the renewable energy sources, solar energy is an environmentally friendly and the fastest growing green energy source. But the main drawback of the PV system is that the power produced by this system is highly dependent on climatic conditions. For example, a PV system could not able to produce any power at night and during cloudy periods. So the PV system intermittently produces power, which means that PV system may not totally satisfy the load demand at each instant. This problem can be solved by combining PV system with energy storage systems such battery bank, ultracapacitor bank, and hydrogen storage tank in a suitable hybrid framework [44–49]**.** For our proposed system we used Li-ion Battery as a storage of power when the PV not available**.**

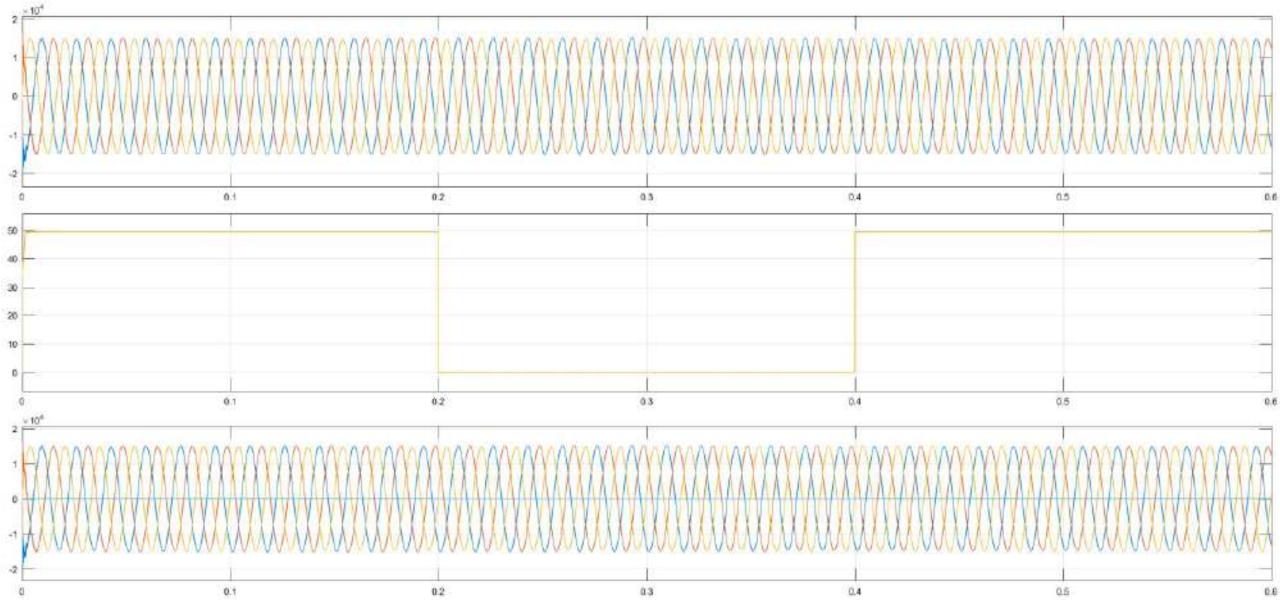

**Fig. 5.13** : Battery to grid and Grid to Battery

The state of charge (SOC) of a cell denotes the capacity that is currently available as a function of the rated capacity. The SOC ranges from 0% to 100%. If the SOC is 100 percent, the cell is said to be fully charged, whereas a SOC of 0 percent indicates that the cell is completely discharged. In practical applications, the SOC is not allowed to exceed 50%, so the cell is recharged when the SOC reaches 50%. Similarly, as a cell ages, its maximum SOC decreases. In **Fig. 5.13** is the Vabc of battery to grid and Vabc of Inverter to Battery which we observed from our designed model's output. This means that a 100 percent SOC for an aged cell is equivalent to a 75 percent –80 percent SOC for a new cell [50]. In our model the  SOC is 40% , the cell is recharged when the SOC reaches 40%. In **Fig. 5.14** graphical output of SOC, battery current and battery Voltage.

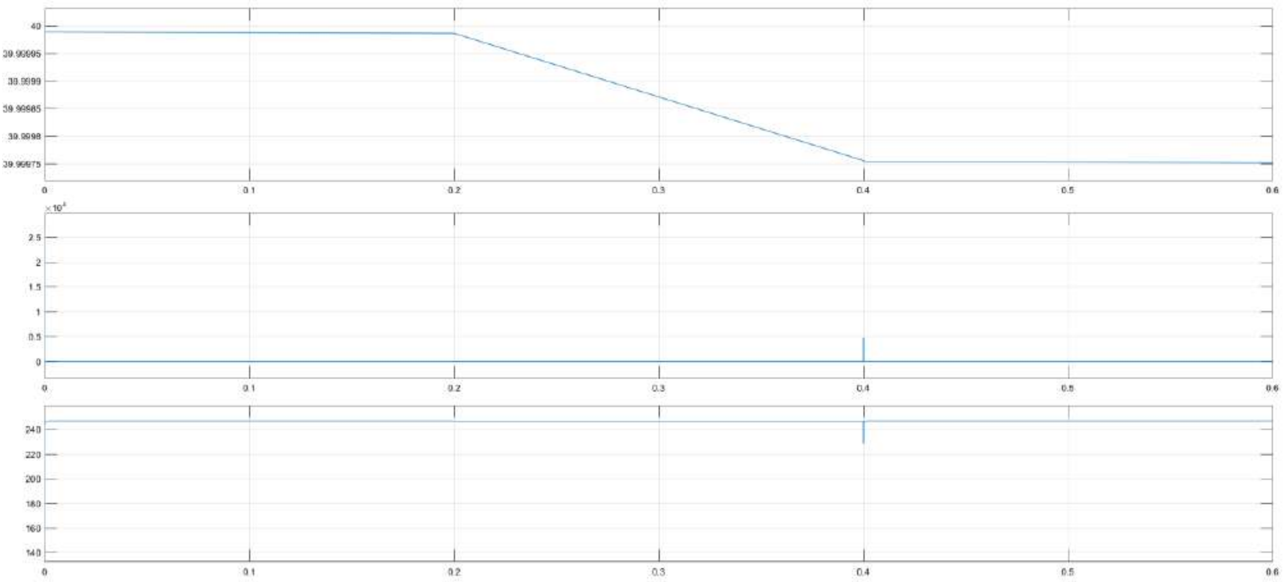

**Fig. 5.14** : state of charge,  battery current and battery Voltage

**5.5 Microgrid**

We connect the PV and wind sources for generating power in our proposed architecture, and the power will be supplied to the microgrid. When we link PV and wind generators to a microgrid, the grid voltage and grid current fluctuate constantly, and the voltage and current are not stable. This is why we connect an LC filter in the grid to reduce noise and fluctuation in voltage and current. The proposed microgrid output voltage and output current **Fig. 5.15** .

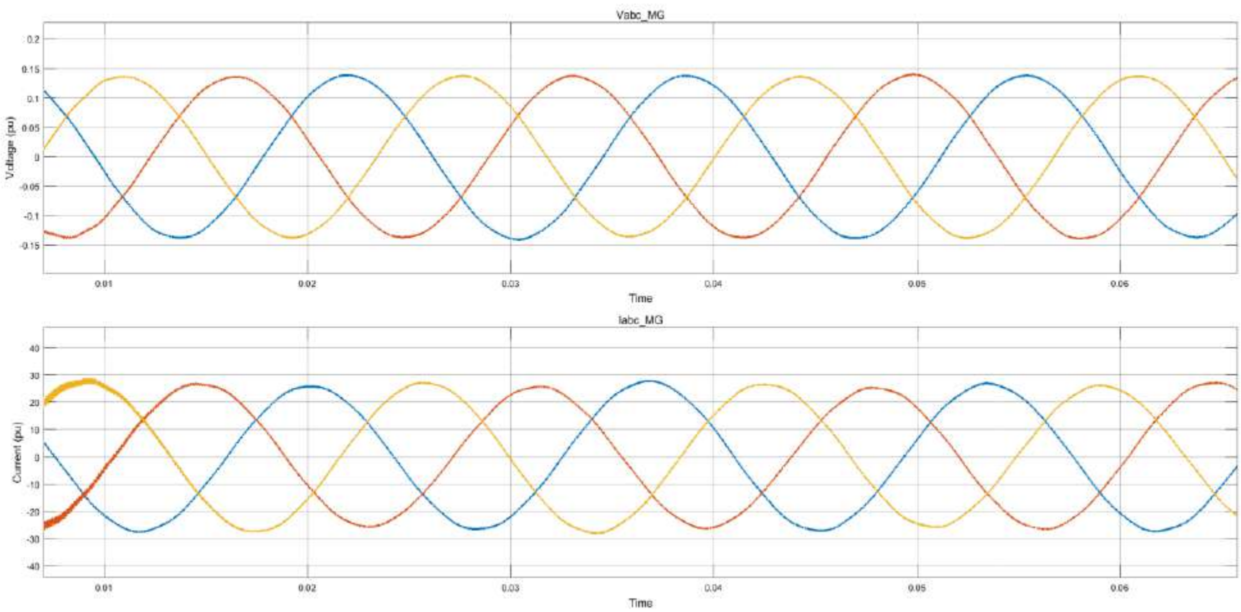


**Fig. 5.15** : Microgrid current and Voltage in pu

## 5.6 Calculation of Wind Turbine

The basic principle of wind mill is to convert the kinetic energy of wind into mechanical energy which is used to rotate the turbine of electrical generator to produce electricity [51]. The kinetic energy of any object is given by-

K.E = ½ m $v^2$ ……………………………………………………………..(1)

m = mass

v= velocity

m is equal to volume multiplied by its density ρ of air,

Mass (m)= ρ AV ……………………………………………………………………..(2)

Combining equation (1) into equation (2) gives

P= ½ ρ A $v^3$…………………………………………………………...…...(3)

Where,

P = wind power (w)

ρ =density of air (1.225 kg/$m^3$)

v = wind speed (m/s)

A=swept area ($m^2$) =D lb

Where,

D = diameter of the turbine(m)

lb = length of the turbine blades (m)

A = 15× 25 = = 375 $m^2$

## 5.7 Theoretical power calculation of WT

**Trail 1**

For velocity = 4.1 m/s

wind power P = ½ ρ A $v^3$

= ½ × 1.225 × 375 × $4.1^3$

=15. 830 Kilowatt

**Trail 2**

For velocity = 4.5 m/s

wind power $P = \frac{1}{2} \rho A v^3$

$= \frac{1}{2} \times 1.225 \times 375 \times 4.5^3$

=20.930 Kilowatt

**Trail 3**

For velocity=4.9m/s

wind power $P = \frac{1}{2} \rho A v^3$

$= \frac{1}{2} \times 1.225 \times 375 \times 4.9^3$

=27.022 Kilowatt

**Trail 4**

For velocity =5.2m/s

wind power $P = \frac{1}{2} \rho A v^3$

$= \frac{1}{2} \times 1.225 \times 375 \times 5.2^3$

=32.295 Kilowatt

**Trail 5**

For velocity= 4.2m/s
wind power $P = \frac{1}{2} \rho A v^3$

$= \frac{1}{2} \times 1.225 \times 375 \times 4.2^3$

=17.017 Kilowatt

**Trail 6**

For velocity = 4.5 m/s

wind power $P = \frac{1}{2} \rho A v^3$

$= \frac{1}{2} \times 1.225 \times 375 \times 4.5^3$

=20.930 Kilowatt

**Trail 7**

For velocity= 4.2m/s
wind power $P = \frac{1}{2} \rho A v^3$

$= \frac{1}{2} \times 1.225 \times 375 \times 4.7^3$
= 42.536 Kilowatt

### 5.8 Theoretical Data

Theoretical Data of wind velocity vs power output shows in the **Table 5.2** and **Fig. 5.16** shows the Wind velocity vs. power output curve.

**Table 5.2**: Wind Velocity vs. power output (Theoretical)

| S/No | Wind Velocity (m/s) | Output(kilowatt) |
|---|---|---|
| 1 | 4.1 | 14.830 |
| 2 | 4.5 | 20.930 |
| 3 | 4.9 | 27.022 |
| 4 | 5.2 | 32.295 |
| 5 | 4.2 | 17.017 |
| 6 | 4.5 | 20.930 |
| 7 | 4.7 | 42.536 |

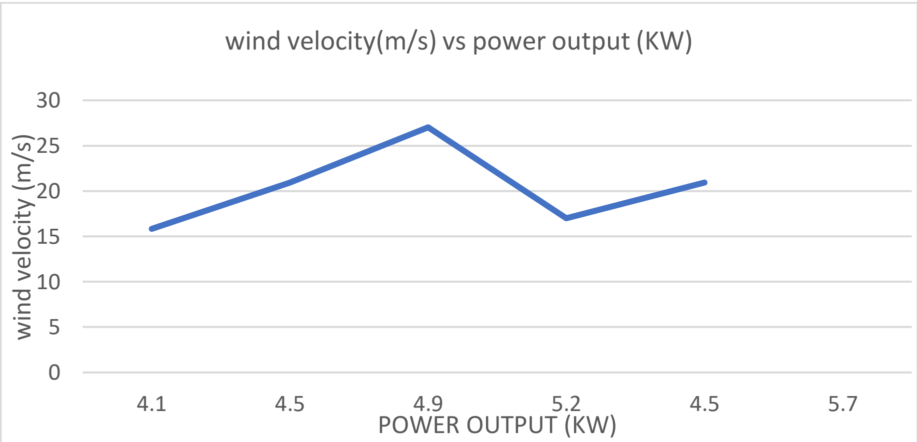


**Fig. 5.16** : Wind velocity vs. power output curve.

### 5.9 Solar Output Calculations

Let’s get into some mathematical formulas. The simple formula for calculating solar panel output is: Average hours of sunlight × solar panel watts × 75% = daily watt-hours .[52].
First, 75% accounts for all the above variables. [52].
Let’s take,
average hours of sunlight in our country is 8 Hours
Our overall solar panel watts is 400 KW

so, 8 hours x 400 x 0.75 = 2400 daily kilowatt-hours.

# CHAPTER-6

# CONCLUSION AND FUTURE SCOPE

## 6.1 Conclusion

This proposed microgrid model contains a photovoltaic solar panel, Wind turbine with energy management system which is simulated by Matlab Simulink . This system consists with 400kW PV array, 1.5 MW wind turbines and a Lithium-ion battery storage as a backup source. This model will be the optimal solution for reducing the shortage demand in the selected area. During normal or peak usage, or at times of the primary power grid failure, a microgrid can operate independently of the larger grid and isolate it's generation nodes and power loads from disturbance without affecting the larger grid's integrity. Bangladesh has a power crisis because power generation is limited. We need to focus on an alternative solution such as microgrid consisting Renewable energy sources. Wind and solar energy provide air-quality, public health and greenhouse gas (GHG) emission benefits as they reduce the reliance on combustion-based electricity generation . Generating energy that produces no greenhouse gas emissions from fossil fuels and reduces some types of air pollution. Renewable energy provides reliable power supplies and fuel diversification, which enhance energy security and lower risk of fuel spills while reducing the need for imported fuels. Renewable energy also helps conserve the nation's natural resources. To reduce the power crisis we can install a hybrid microgrid model near the river side or beach side of Bangladesh.

## 6.2 Future Scopes

1. Optimizing grid operation to improve the performance and efficiency of electricity transmission and distribution system.
2. Halishahar area is besides bay terminal road ,where we can set Vertical axis wind turbine to get more electricity production and this road is suitable to set vertical axis wind turbine.
3. The experiment set up is placed at the base level and the same setup may be tested at a different height. It has tested with one profile of blade and the profile of the blade may be changed for better efficiency.
4. Improve the design of Horizontal axis wind turbine to reduce more operation cost, implementation cost .

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