A NEW APPROCH FOR EFFICIENT WIND POWER GENERATION THROUGH HELIX WIND TURBINE

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A Thesis submitted to the Department of Electrical and Electronic Engineering Of BRAC University, in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

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Declaration

We hereby declare that

1. The thesis submitted is our own original work while completing degree at BRAC University.

2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.

3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.

4. We have acknowledged all main sources of help.

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Abstract

With the increase in demand for clean and green power, the use of renewable energy technologies is increasing day by day. The electrical power engendered by wind energy using wind turbine yields mechanical power. This power can be converted into electrical power by using induction generator. The idea of this thesis is to develop new approach in which a type of wind turbine called helix turbine will be used instead of horizontal axis wind turbines to generate electrical power with much more efficiency than before. We are working on the efficiency difference between these two wind turbines and the way to distribute more efficient power with helix wind turbine.

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Chapter 1

Introduction

1.1 Evaluation of Power Energy

Power is the most important thing for the development of a country like Bangladesh. In Bangladesh, the mandate for power is growing day by day, but the foundations of energy are not growing in pleasing side by side. The progress rate of mechanization in Bangladesh has reduced miserable due to the unavailability of energy resources.

Wind can be a resolution to this difficulty. Wind energy has the prospective to make available powered energy or electricity without breeding waste products. Energy of wind was the leading cast-off foundation of energy in the antiquity of manhood. It has been placed to the procedure intended for nearby 5000 ages.

Throughout the previous periods, the machinery of wind turbines upgraded very dissolutely. Primary wind helms just manufactured combine with a smaller amount of kWh; new turbines at this are often ready to yield a lot of kWh per annum through rated power up and around 6 MW. Meanwhile, the demand for energy and more specifically electricity has increased so dramatically over the last 100 years; it's now become important to think about the environmental impacts of energy production. During the traditional, in elevation criteria of existing also present existences constructed on improved energy depletion.

1.2 Power Energy in Bangladesh

Wind generation knows the way to be an appropriate essential means of explaining the continuing energy predicament in Bangladesh. In wind generation arrangement Bangladesh devises admirable prospect topographical location. Many analyses work on the wind generation system in Bangladesh. The government Engineering Department (LGED) and Bangladesh Power Development Board (BPDB) are performing on this research. One among the projects works the

Muhuri Dam. It rated a capacity of 0.99 MW. Muhuri Dam research mechanism points out wind generation potential capacity of 100 MW. For the amount of the Rainy, season winds are outstanding in Bangladesh and also formerly and afterward one to 2 months. Months beginning from late October to the intermediate of February, whichever wind is just too dawdling to be of several procedures by a turbine. That time out four months, a windmill appropriately deliberate and positioned, can wind energy to be profitable. Wind speed during a diverse a part of Bangladesh indicates the best potential opportunities for minor, standard and great measure of wind generation in dissimilar parts of Bangladesh should be wind generation probability.

1.3 Introduction of OpenDSS

OpenDSS is an electrical power distribution system simulator (DSS) premeditated to sustenance distributed energy resource (DER) grid incorporation and grid transformation [24]. It empowers engineers to accomplish multifaceted investigates consuming a malleable, customizable, and informal procedure stand anticipated definitely to return across up-to-date and forthcoming dissemination arrangement experiments and offers a ground intended for considerate and participating innovative machinery also properties. It had been established in 1997, the DSS remained formerly considered towards justification on behalf of the amount besides locational grid influences of DER through presenting the impression of quasi-static time-series (QSTS) investigation to the electrical power industry [25].

To synchronize also develop smooth grid submissions; the DSS was open-sourced ten years far ahead. By means of quite 65,000 copies and thousands of world-wide operators, the OpenDSS consumes a controlling simulation implement during the manufacturing via conveniences, exploration laboratories, and academies for demonstrating and simulating unconventional dissemination submissions. Furthermore, things are castoff by means of preparation implement used for undergraduates besides innovative dissemination engineers.

1.4 Purpose of Work

The purpose is to transform the plentiful kinetic energy that is present in wind, towards electrical energy that we can procedure to power the whole thing in our daily life that depends on electricity. Because of this, they gross a transitional period which transforms the kinetic energy in the wind to the mechanical energy (spiraling the turbine). In adult windmills, folks influence to procedure mechanical energy straight to do beneficial exertion.

Currently, it is speedily transformed to electrical energy also nourished on top of the electrical grid. Helix Turbine is one of the turbines which produce mechanical power in water torrent in the path of water movement. It is a vertical axis wind turbine that was founded by a renewable energy company in 2005. Its goal is to distribute great features, more effective, less expensive, and conservational friendly power energy resolution which can be functional for both urban and rural areas.

1.5 Contribution of this Thesis

Our motive to show all the reasons why Helix turbine is better than Horizontal turbine. We will prove it by differentiating between them. On the other hand, we try to find the efficiency difference between the helix turbine and horizontal turbine. We know the efficiency of the turbine is the ratio of output power compared with input power.

1.6 Overview of Working

In this paper at first, we put all the description of two types of the turbine which is helix and horizontal turbine. We give all the descriptions about each and every component of these two turbines with pictures. For example, nacelle, hubs, rotor, generator. After that, we try to show why the helix turbine is better than the horizontal turbine to generate electrical power more than before with valid reason and description. We also find out the efficiencies of these two turbines and the efficiency difference between two of these turbines also find a way to distribute more efficient power with helix turbine.

Not only that we also show it in MATLAB simulation. As we know MATLAB has controlling built-in sequences that permit a very extensive diversity of calculations. It also has informal to practice visuals guidelines that make the conception of consequences proximately accessible. Specific presentations are composed in sets mentioned as a toolbox. There are toolboxes for signal processing, symbolic computation, control theory, simulation, optimization, and numerous additional grounds of functional science and engineering. We use MATLAB for simulations and show it more efficiently.

Chapter 2

Wind Turbines and Its Classifications

2.1 Wind Turbine

A device that turns the wind energy into the electrical energy is wind turbine [18]. The wind turbine uses kinetic energy of the wind and converts it into electrical energy.

Bigger turbines can be utilized for domestic power supply, while surplus power can be sold back to the energy provider via a power grid. The wind turbines cover a broad variety of sizes. Small rooftop wind turbines rated at 400W to 1KW can generate up to 24KWh electricity on a day [19] and a large commercial wind turbine rated at 2.5-3MW can produce up to 16.67MW electricity in a day[20].

2.2 Classifications of Wind Turbines

The axis orientation of rotation mainly classifies wind turbines into two categories. They are:

- Horizontal Axis Wind Turbine (HAWT).
- Vertical Axis Wind Turbine (VAWT).

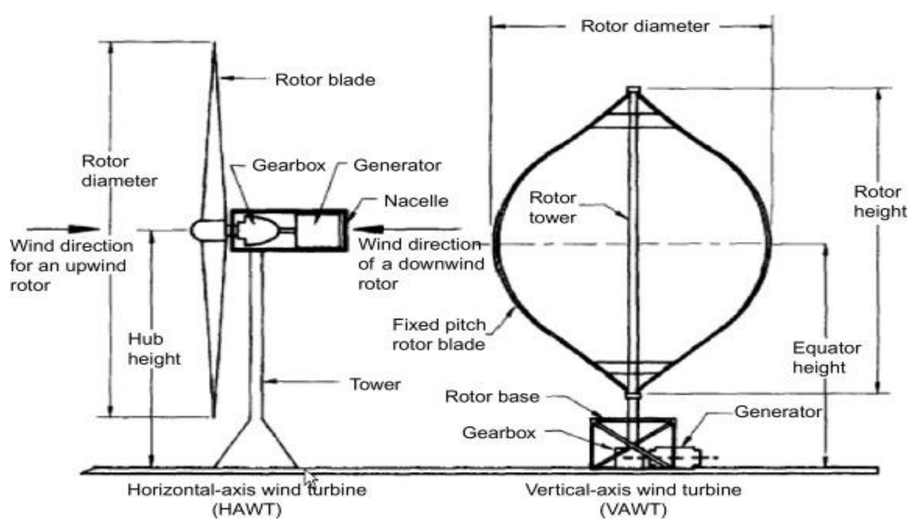

Figure 2.1: Classification of Wind turbine [16]

2.3 Horizontal Axis Wind Turbine (HAWT)

Horizontal Axis wind Turbines are the most commonly used wind turbine among all other wind turbines. It consists of two or three blades. It runs at high blade tip level. The blades of HAWTs are usually aerodynamic blades, and it is fitted to a rotor for generating electricity. These rotors may be either upwind or downwind located as shown in Figure 2.2. The turbines with upwind rotor need a yaw mechanism or a tail propeller to orient into the wind. On the other hand, downwind rotors can orient on its own because of cones blades [16].

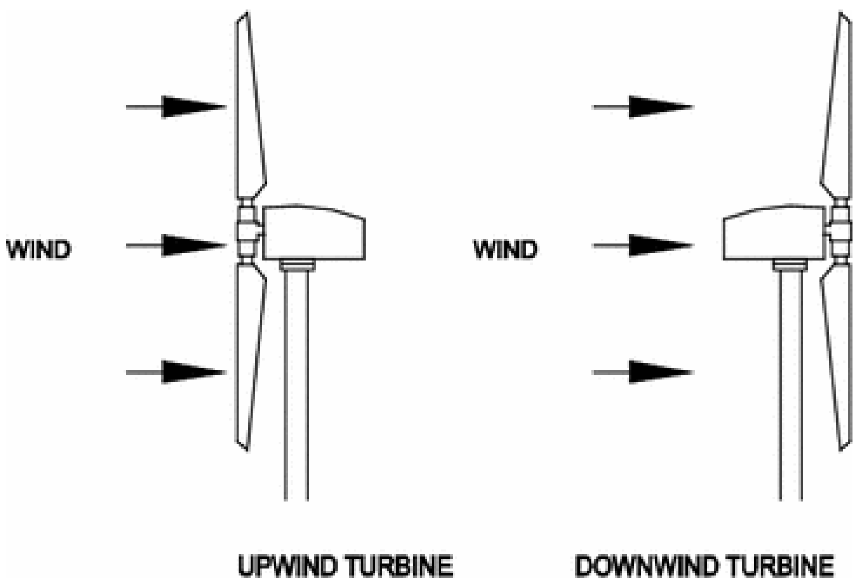

Figure 2.2: Upwind and Downwind turbine [16]

Now a day, the advanced HAWTs uses aerodynamic lifting force to transform the rotor blades [Figure 2.3]. As air travels through the upper and lower position of the blade, the air moves through the top of the blade more quickly than the lower portion because of the blade's curvature. On the top side, a lower-pressure region is created. Thus, when a pressure difference is created between the upper and lower sides of the blade, it produces an exertion in the upper direction of the blade. The lifting force works against the comparative wind on the wind turbine's side [Figure 2.4]. The lifting force works side by side with the airflows. This theoretical advancement helps the rotor to rotate at a great speed despite of depending on drag forces. Most of the Horizontal Wind Turbines are designed such a way that it can maximizes the lift force and minimizes the drag force to generate more energy [16].

In larger Horizontal Wind Turbines electronic controls and anemometers is used so that they can orient themselves by detecting the wind directions

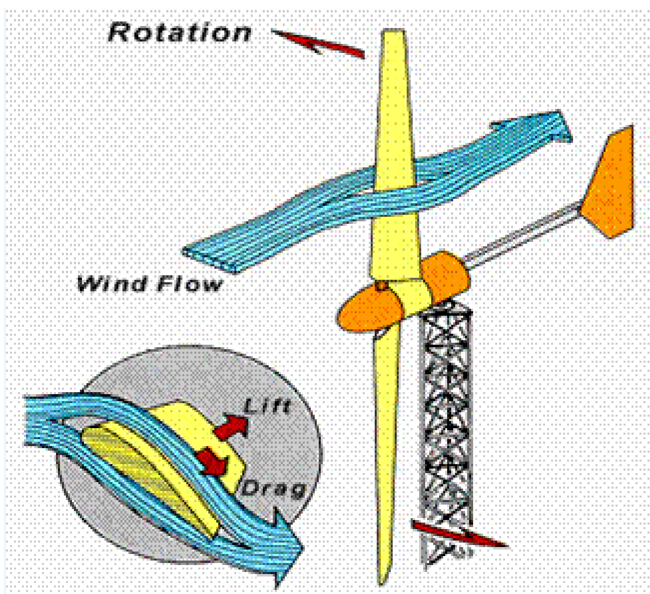

Figure 2.3: Aerodynamic lifting force

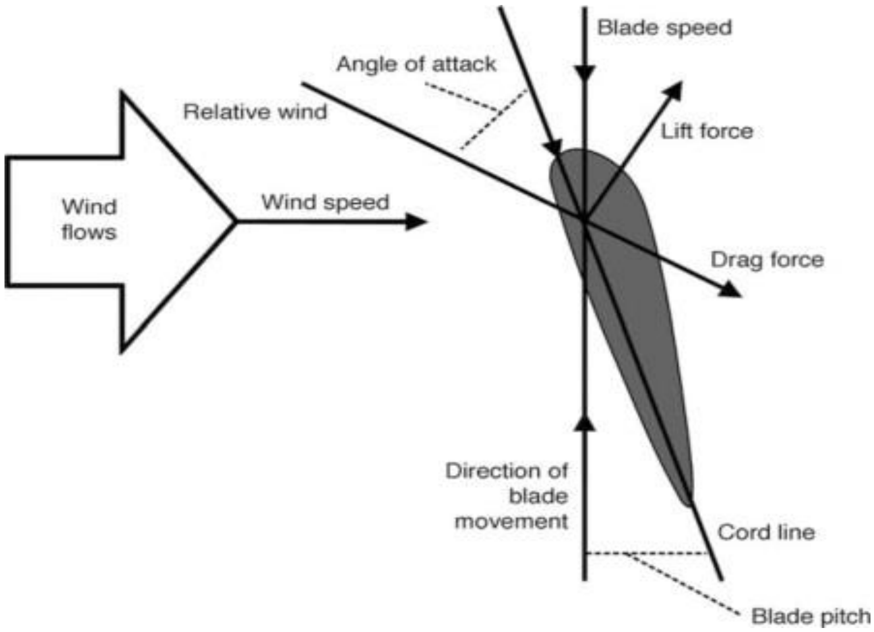

Figure 2.4: Working principle of lifting force [16]

2.4 Components of Horizontal Axis Wind Turbine

As shown in the Figure 2.5, the main components of a Horizontal Axis Wind Turbine [17] are:

- Foundation
- Tower.
- Blades.
- Nacelle.
- Hub.
- Drive shaft.
- Rotor.
- Generator.

- Gearbox.
- Yaw Mechanism.

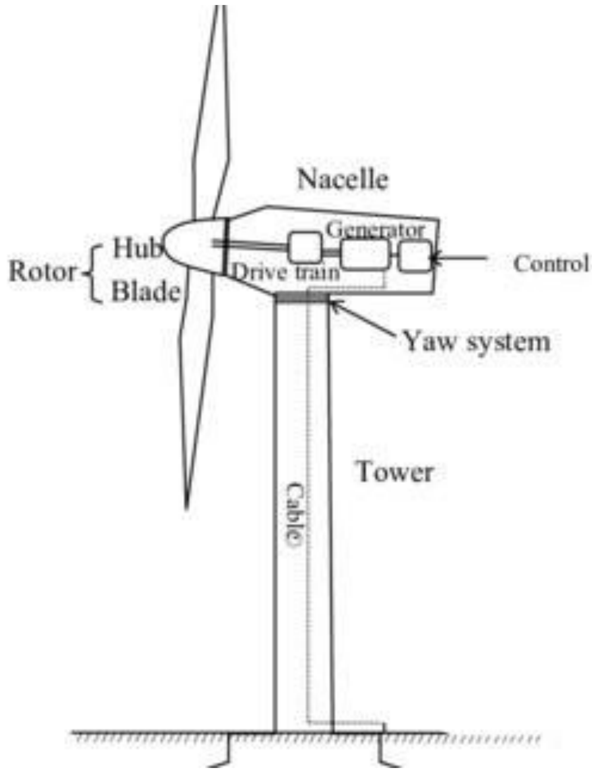

Figure 2.5: Main components of horizontal axis wind turbine [29]

2.4.1 Foundation

The first and foremost aspect of the wind turbine is foundation [17]. To support tower and different sections of a wind turbine, an outstanding foundation is required [Figure 2.6].

2.4.2 Tower

The tower is constructed of stones, concrete or lattice steel. The nacelle and rotor hub are mostly protected by a tower [Figure 2.6] [17]. The height of the tower is relative to the wind system's output. The wind system's output capacity increases with the rise in height. The taller the tower is, the more wind speed we can get. Taller tower also reduces the turbulence in wind.

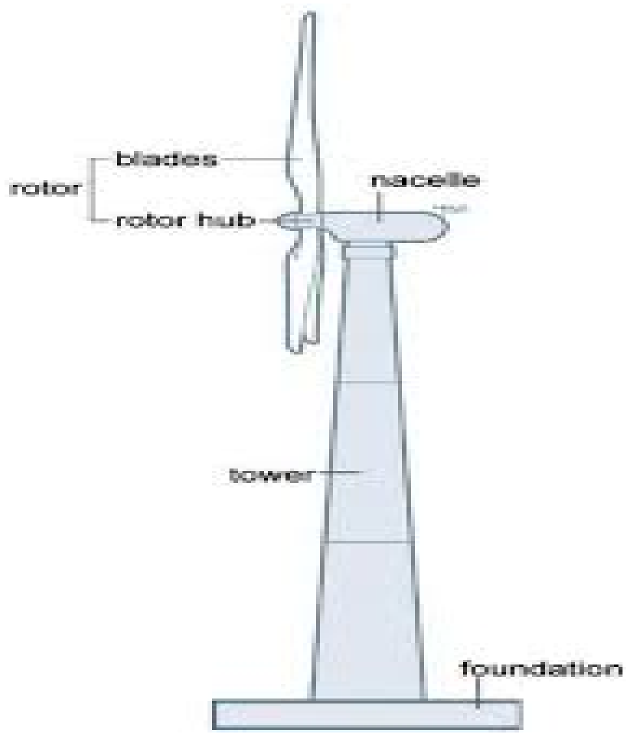

Figure 2.6: Foundation and Tower [29]

2.4.3 Blades

The driving force of wind is turned into mechanical energy by blades. Blades are mainly constructed by fiberglass-reinforced polyester or wood-epoxy. The blades of HWATs are mainly of three [Figure2.7.1, Figure 2.7.2 & Figure 2.7.3]

1. Single bladed.
2. Two bladed.
3. Three bladed.

Most of the Horizontal Axis Wind Turbines are now mainly three bladed. Blades are connected to the rotor hub.

Single Bladed Horizontal Axis Wind Turbine	**Two Bladed Horizontal Axis Wind Turbine**	**Three Bladed Horizontal Axis Wind Turbine**
• Single bladed turbines have been so unusual for days now. It has many disadvantages. Like as: shadow effects, less stability. It also requires counter weights on the other side of the blade for balancing issue. The only drawback of this is that, it decreases the cost and the weight of the turbine [15].	• The only advantage of it is that, it reduces the cost and the weight of the turbine [15].	• Three blade HAWTs are most commonly used now a days. It also produces higher output. Three blade HAWTs also provide more blade surface for converting wind energy, limiting noise and vibration [15].

Figure 2.7.1: Single Bladed Horizontal Axis Turbine [15]

Figure 2.7.2: Two Bladed Horizontal Axis Wind Turbine[15]

Figure 2.7.3: Three Bladed Horizontal Axis Wind Turbine [15]

2.4.4 Nacelle

A nacelle is a house that restrains all the components necessary for effective functioning. A nacelle is placed on the peak of the tower. Nacelles consists of, rotor, gearbox, hub, generator, hydraulics, bearings, inverters [Figure 2.8]. The nacelle holds more than 1500 small and large parts and components. Depending on the producer and power-rating, it can be up to 50-ft long and 300 tons in weight.

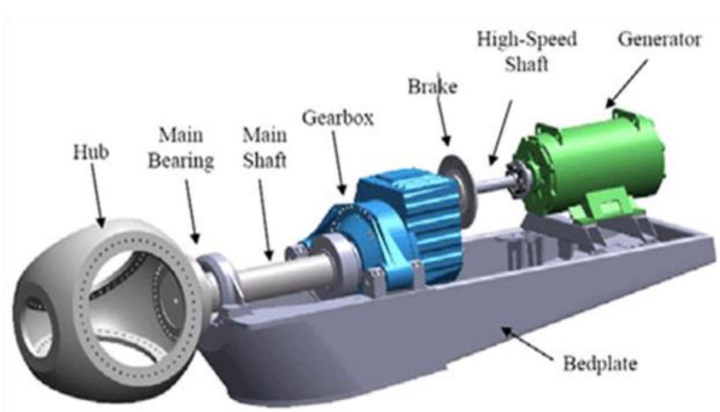

Figure 2.8: Nacelle [30]

2.4.5 Hub

A rotor hub is primarily designed for the rotor blade and shaft coupling of the turbine. The hub connects the blades to the main shaft and finally to the rest of the drive train. In a hub, the hub bolts, blade bearings, pitch mechanism, and internals fit together. The hubs are manufactured of welded sheet steel, forged steel and cast iron.

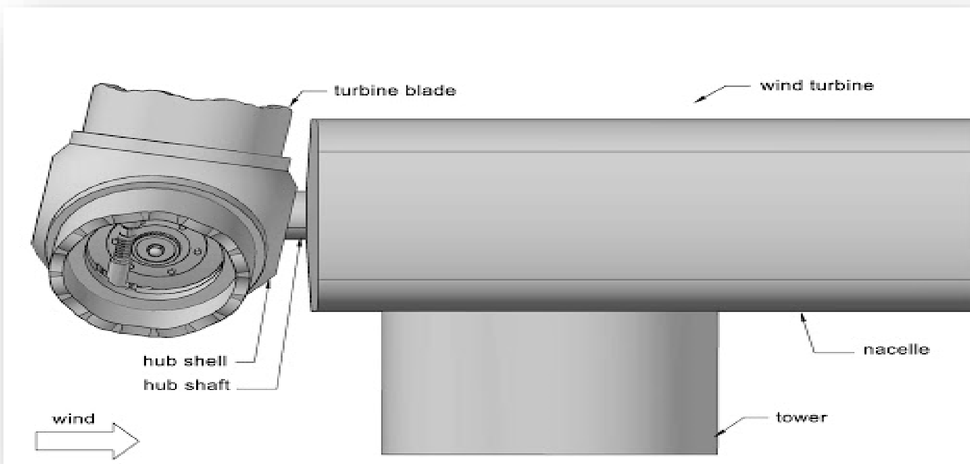

Figure 2.9.1: Hub [31]

As shown in Figure 2.9.2, there are three types of hubs:

1. Rigid Hub: The rigid hub is used to maintain all the major components in a fixed position relative to the main shaft. A rigid hub must be solid enough to handle all the loads that can come from any aerodynamic loads in the blades and dynamically driven loads, such as those due to rotation and yawing.

2. Teetering Hub: The teetering hubs are found in nearly all two-bladed wind turbines. Due to aerodynamic imbalances or loads due to the rotor rotation of the turbine or yawing dynamic effects, the teetering hub may reduce loads. The teetering hubs are much more complex compared to the rigid hubs.

3. Hinged Hub: The hinged hub is fundamentally a combination of a fixed hub and a teetering hub. It is generally a rigid hub with hinges for the blades.

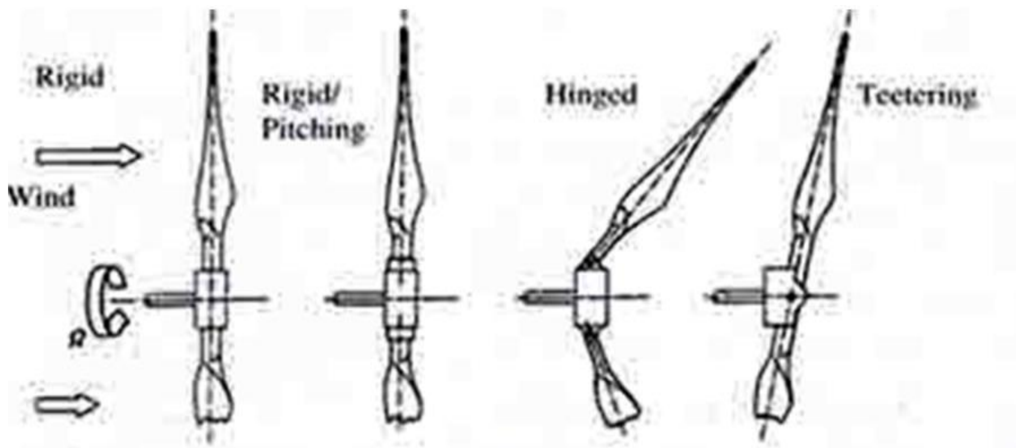

Figure 2.9.2: Classification of Hub [32]

2.4.6 Drive Shaft

Drive shafts transfers rotational mechanical energy from blade hub to the generator to generate electricity [15]. Drive shafts are an empty or strong steel solidified shaft beneath exceptionally high stresses and impressive torque. A wind turbine is usually made of two shafts, as shown in Figure 2.10.

1. Main shaft: The main shaft is attached to the gear box between the blade hub and the input. Main shaft is called the "Low-Speed Shaft" because of its low-speed rotation.

2. Generator shaft: The generator shaft mainly attaches the output of the gearbox to the output of the generator. It is called the "High Speed Shaft" because of its high-speed rotation.

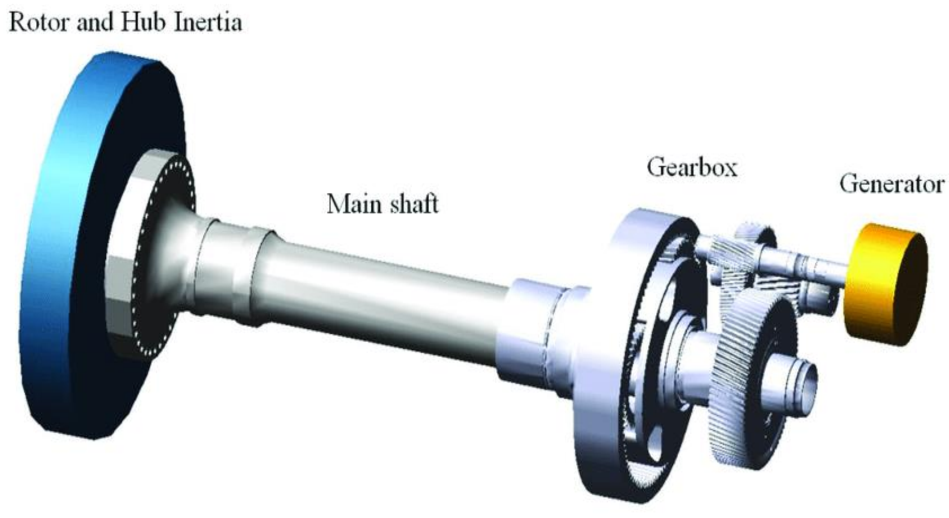

Figure 2.10: Drive shaft [15]

2.4.7 Rotor

Rotor mainly converts the kinetic energy of wind to mechanic energy. It is basically the formation of blades and hub together [Figure 2.11]. It is very essential to provide the flawless features of rotor and rotor blades [15]. Rotors are constructed in term of some factors such as air density, wind turbine’s height, wind speed, aerodynamic structure and blade's movement area [15].

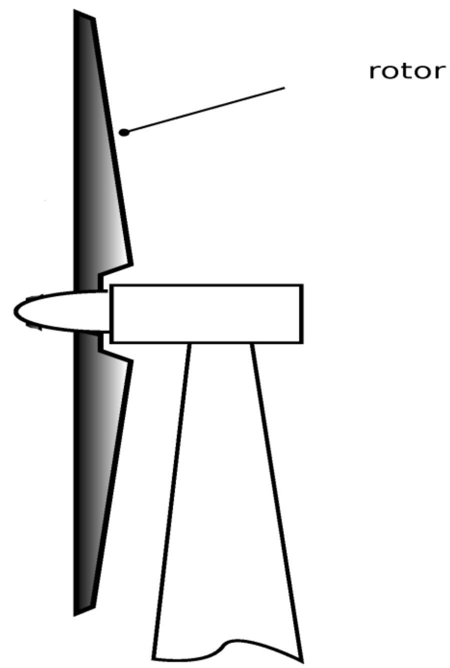

Figure 2.11: Rotor

2.4.8 Generator

The generator transforms electricity from the spinning rotor shaft to electrical power that can be used on site distributed to the grid. It can be synchronous or asynchronous. The standard rotation speed of a generator is 1000 -3600 rpm [15]. These speeds are way too fast for a wind turbine for many reasons, as well as intense strain and high-speed turbulence and the actual velocity of the outer edge is constrained by that of the speed of sound (340.3 m/s) related to both unnecessary drag and buzz produces by

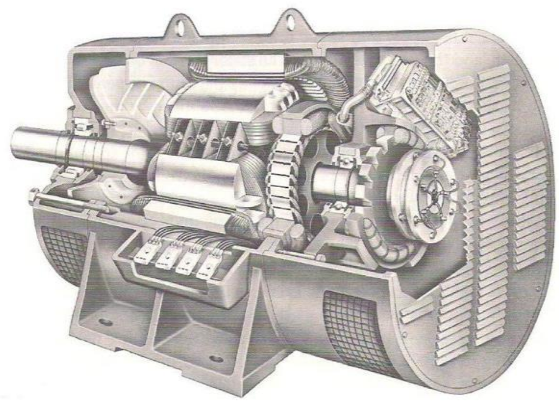

Figure 2.12: Generator [15]

2.4.9 Gear Box

Gear box is the main component of wind turbine main shaft drive [Figure 2.13]. The shaft of a wind turbine, which rotates with the heavy blades and hubs, rotates way too slowly for the conventional generator to generate energy effectively [15]. A gearbox is used to link the shaft and rotate the second shaft at a much higher rotational speed. Inside the motor. The fast-spinning shaft rotates and generates electricity. To accomplish this high multiplication of the rotational frequency from the slow-turning shaft to the fast-turning shaft, a gearbox usually uses gears in three phases [15].

There are two main types of gear transmission:

1. Cylindrical Gear Transmission.
2. Planetary Gear Transmission.

Figure 2.13: Gear box [33]

2.4.10 Yaw Mechanism

As the wind direction changes, the rotor is rotated in the upwind direction by the Yaw mechanism [15]. To turn the rotors into upwind direction by yaw mechanism, an electric motor and gear box is used.

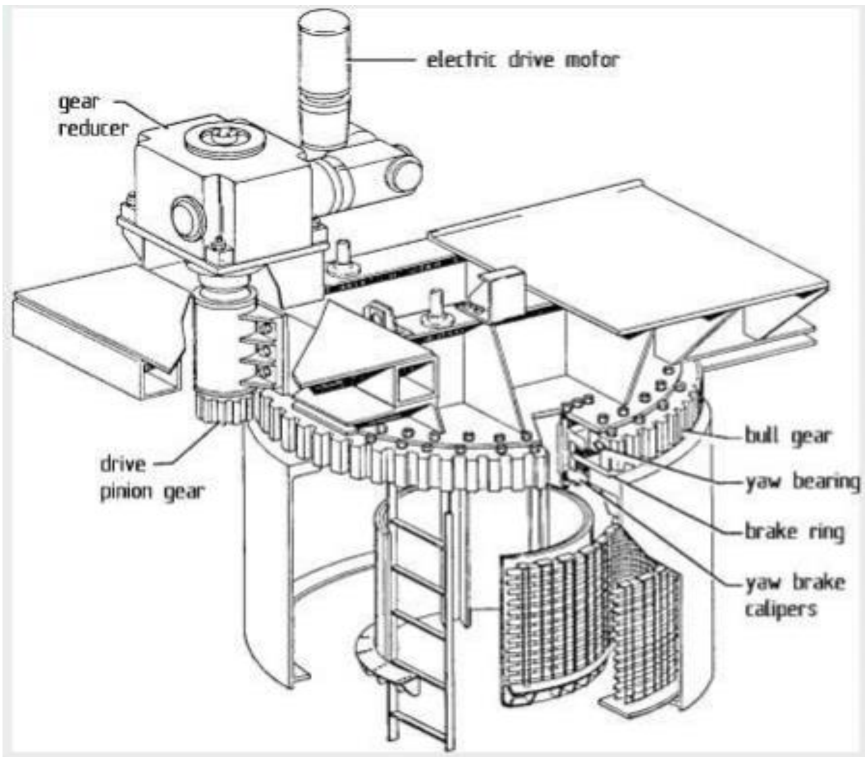

Figure 2.14: Yaw mechanism

2.5 Vertical Axis Wind Turbines

The Wind Turbines in Vertical Axis are a special sort of power-generation technology. For places faraway from interconnected grid networks, vertical axis turbines provide promising alternatives. This turbine is straightforward to put in and use [14]. Moreover, those Turbines in wind farms could also be stacked thoroughly organized, permitting extra during a given space. So as to supply electricity, vertical axis turbines don't need the maximum amount wind. Where wind speed is lower, turbines allowing them to be closer to the bottom. One among the most issues with the Vertical Axis turbine is that the need for an initial force to start out rotating the turbine. Another thing is that it's hard to create them for top altitudes [14]. It doesn't need a yaw system because it can utilize wind from any direction and it is an advantage over a Horizontal axis turbine.

Figure 2.15: Vertical axis wind turbines

Vertical Axis Turbines are mainly of two types. They are:

1. Savonius Wind Turbine. (Drag Driven).
2. Darrieus Wind Turbine. (Lift Driven).

Besides this two, Vertical Axis Turbines have two more types according to shapes.

1. H-Darrieus Wind Turbine.
2. Helix Shape Wind turbine.

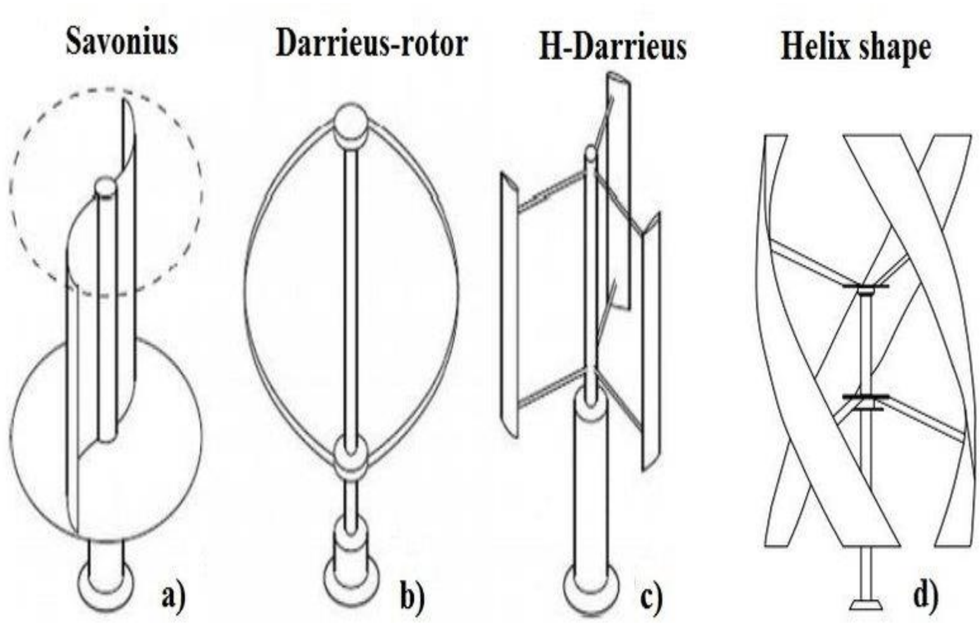

Figure 2.16: Classifications of Vertical Axis Wind Turbine [13]

2.6 Components of Vertical Axis Wind Turbine

The components of vertical axis wind turbines are generally [12]:

- Base.
- Guide wire.
- Hub.
- Rotor.
- Rotor Blades.
- Shaft.
- Braking (Electrical and Mechanical)
- Gear Box.
- Generator.

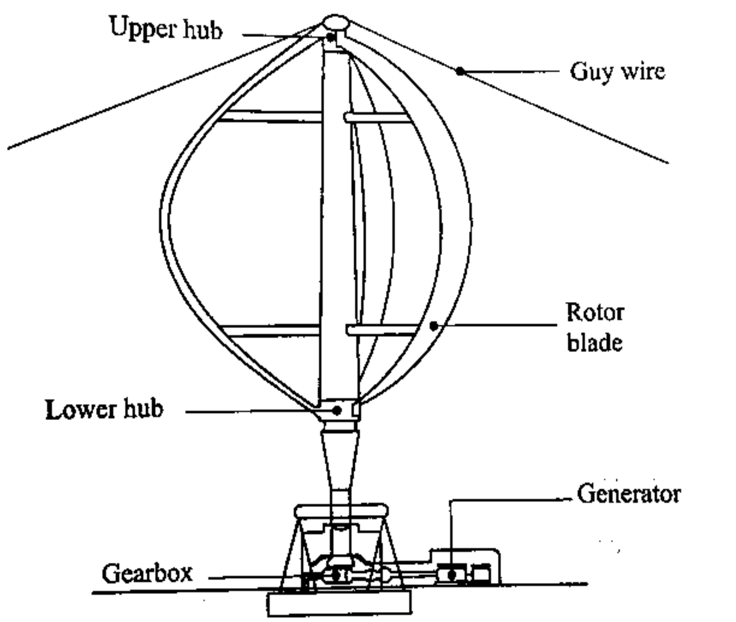

Figure 2.17: Components of vertical axis wind turbine [12]

2.6.1 Base

Usually, the bottom or the rooftop of the building on which it's installed is the base of Vertical Axis Wind Turbine.

2.6.2 Guide Wire

For maintaining the rotor shaft in a permanent point, guy wire is used [12]. It provides both the required strength and stiffness. It also maximizes the possible mechanical vibration.

2.6.3 Hub

There are two hubs in vertical axis wind turbines, one is lower hub and the other is upper hub. At the center of the rotor, the hub is installed [12]. The hubs are attached with the rotor blades and they are placed at two points (lower hub & upper hub). The hub is made of cast iron or cast steel.

2.6.4 Rotor

The rotor is formed from several rotor blades and is connected to a hub. The rotor turns the wind's K.E. into mechanical motion. That is often the core of the turbine. Now Vertical Axis turbine, the diameter of the rotor shows a crucial role. If the typical rotor design diameter increases, so do the quantity of energy that will be converted from the wind by the rotor [12].

2.6.5 Rotor Blades

In a vertical axis turbine, rotor blades are an important and elemental portion. Rotor blades transform the wind's kinetic energy into the hub's rotation. Rotor blades are usually made from, fiberglass, carbon fiber or aluminum [12]. Within the Vertical Axis turbine, there are two sorts of rotor blades. They are:

1. Savonius wind turbine. (Blades which Drag force).
2. Darrieus wind turbine. (Blades which Lift force).

2.6.6 Shaft

Essentially the shaft is connected to the turbine blades. It revolves with the turbine blades. Shaft is linked through the generator while rotating [12].

2.6.7 Braking

The braking system is essentially used on a vertical axis turbine to stay the turbine speed within a limit. The electrical braking system of a turbine uses a current detection circuit [12]. Small wind turbine's braking can also be done by discard the energy from the generator into a resistor bank or converting the rotational K.E. of the turbine into heat [12]. This approach is beneficial if the kinetic load of the generator is unexpectedly decreased or is just too insufficient to take maintenance of the turbine speed in limit.

In an urgent situation, to guard the turbine a mechanical brake or disk brake is utilizes. On a high-speed shaft among the gearbox and therefore the generator, a mechanical brake is applied [12]. The brake is usually used as a secondary thanks to keeping the turbine at relaxation for conservation, mainly indicating that the rotor lock mechanism is. A fireplace within the nacelle is often produced if the mechanical brake is employed to prevent the turbine from full speed. It increases the load on the turbine if the brake is applied at rated rpm. Hydraulic systems drive this type of mechanical brake and fasten it to the most control box [12].

2.6.8 Gear Box

The shafts low perceptive speed is gearboxes key process and increases it to extend the rational speed of the generator. Gearboxes are made from stainless steel, cast iron, and aluminum alloys [12]. Gear stages are:

1. Planetary.
2. Helical.
3. Parallel shaft.
4. Spare.
5. Worn.

In certain stages, two or more gear types can be merged [12].

2.6.9 Generator

A generator transforms mechanical rotational energy into electrical energy. The speed of rotation of the wind turbine is usually slower than the corresponding rotation speed of the electrical network. A wind generator generally rotates at 5-20 rpm. On the other hand, directly connected machine has an electrical speed between 750-3600 rpm. For this reason, between the rotor hub and the generator, a gearbox is installed. It further decreases the cost and weight of the generator.

2.7 Savonius Wind Turbines

Sigurd Johannes invented a Savonius turbine in 1922 [11]. It's a drag type vertical axis turbine. In low-slung wind speed, the Savonius turbine functions well. Most of the Savonius is consists of two or three blades. The Savonius turbine is constructed of half-cylindrical elements connected to the other side of the vertical shaft [11].

Figure 2.18: Savonius wind turbine [35]

2.7.1 Functional Principle of Savonius Wind Turbine

The operating theory of Savonius turbine is quite simple. To drive curved blades, the Savonius wind turbine uses drag force, which rotates the rotor by producing a torque [Figure 2.19]. The convex and concave parts of blade create a difference of drag force, which rotates the rotor. In the concave section, the air is stuck and drives the turbine. A drag that is lower than the one on the concave part is generated by the flow that reaches the convex part. It is the drag force differential which causes this turbine to rotate.

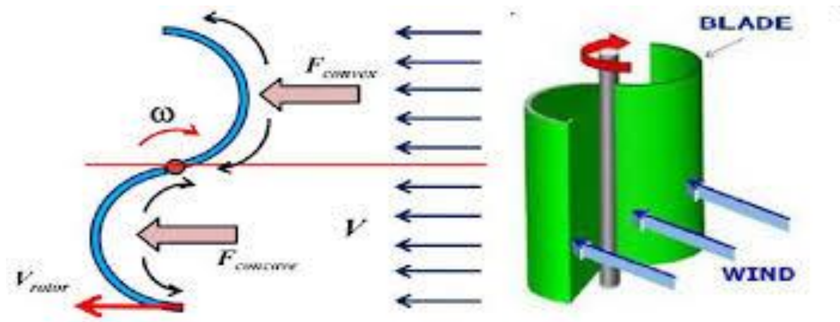

Figure 2.19: Functioning principle of Savonius wind turbine [34]

2.8 Darrieus Wind Turbines

Georges Jean Marie Darrieus invented the Darrieus turbine in 1920s. Darrieus turbine is known as lift-type vertical axis turbine [10]. The Darrieus wind turbine's shape is like an eggbeater [10]. The blades of the Darrieus are airfoils. The curve of the blades minimizes the bending moment arising from the centrifugal forces to the rotating blade [9].

Figure 2.20: Darrieus wind turbine [36]

2.8.1 Functional Principle of Darrieus Wind Turbine

The Darrieus turbine uses the lift-force to rotate the rotor also produce electricity. Though the Darrieus turbine uses lift force like Horizontal Axis Turbine, the functional process is sort of dissimilar from the Horizontal Axis turbine [Figure 2.21]. The movement of the airfoils through the air generates a clear wind compared to the blades that rotate after the Darrieus turbine starts to spin. The wind is increased by this relative airflow, which ends up during a combination of forces. This creates a force within the rotor that causes a net positive torque, causing the airfoils to rotate within the same direction as they initially did [8]**.**

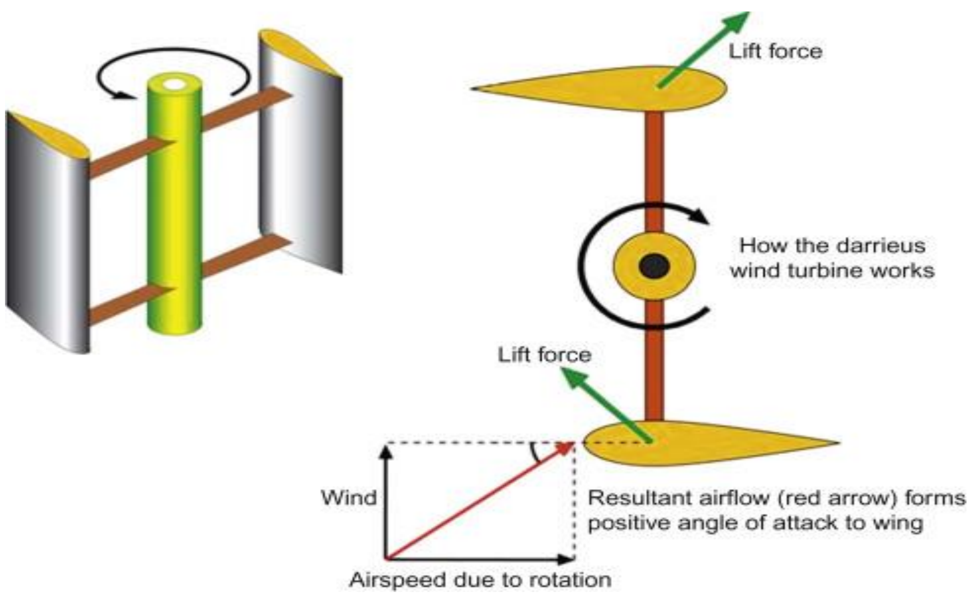

Figure 2.21: Working process of Darrieus wind turbine [8]

2.9 H-Darrieus Wind Turbine

A more powerful variant of the Darrieus wind turbine is the H-Darrieus [6]. It is also known as Giromill [7]. It is shaped as "H" which is why it is called the H-Darrieus [Figure 2.22]. The H-Darrieus have two versions according to blades [6]

1. Two-blade version.
2. Three-blade version.

H-Darrieus blades are simpler to produce and deliver higher performance. The operating principle is as same as the Darrieus wind turbines. The form of the blade is the only change in the H-Darrieus.

Figure 2.22: H-Darrieus wind turbine [37]

2.10 Helical Wind Turbine

The helical wind turbine has a spiral design which catches the air to produce electricity. Many helical wind turbines look like DNA structure. Helical turbines are quieter than the other turbines. Helical turbines commonly castoff in ranges within advanced wind speed. Helical wind turbines are less vulnerable than bladed turbines [1]. It also does not need a tail-fan to hold them pointing in the ideal direction [1]. Helical turbine is also self-starting.

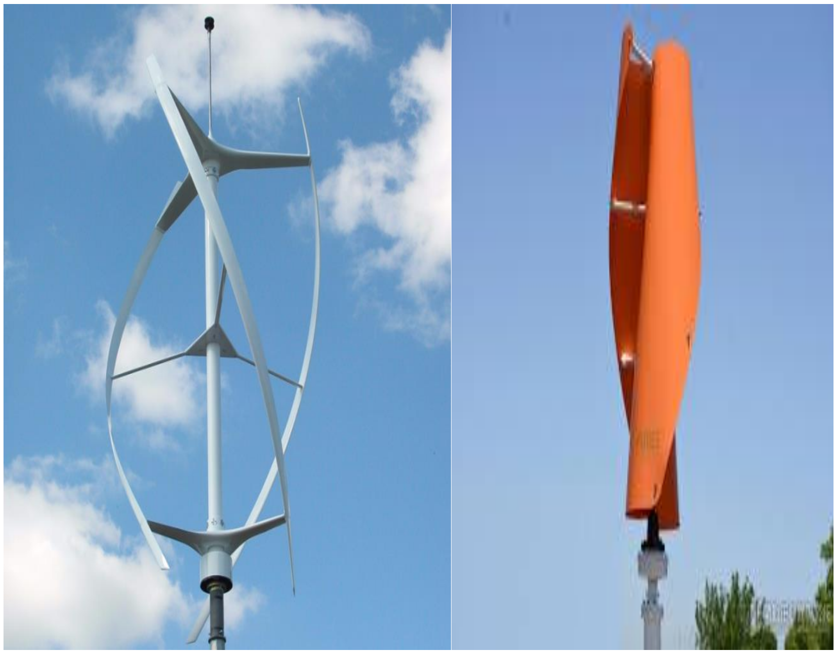

Figure 2.23: Helical wind turbine [38]

2.11 Components of Helical Wind Turbine

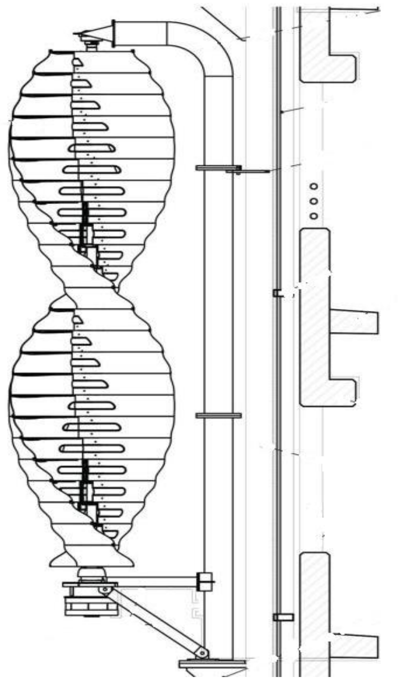

Figure 2.24: Components of Helical wind turbine

2.11.1 Blades

Helical wind turbine consists of two or three blades. The air passes through the blades produces lift and starts to spin.

2.11.2 Generator

The generator of the helix turbine is basically weather sealed magnet generator (6KW), direct drive and mechanically integrated.

2.11.3 Rotor

Together, the blades and the hub form the rotor.

2.12 Benefits of Helix Wind Turbine

- Helix Wind Turbines are Omni-directional [2]. So, helix wind turbines do not need to turn and track the wind.
- Its installation is easy and does not need to be operated further [3].
- The exhaustion of the gearbox is less than the other [5].
- The gearbox can replace easily because the gearbox is located at the ground level.
- The blades are less costly than other wind turbines.
- It can be nearer composed in wind power plant as it can operate in turbulent wind well.
- Helix wind turbines can generate additional power in per unit of land-living associated to the group of widely-spaced horizontal axis wind turbines [4].
- It can function quietly and has less noise emission [5].
- It needs a less-starting wind force than the Horizontal Axis Wind Turbines [5].

Chapter 3

Wind Energy & Helical Turbine

Mathematical Expression

3.1 Energy in Bangladesh

Bangladesh has over 160 million people. Among these population 95% of urban people and 66% of rural people can have access to the electricity in Bangladesh. This has an average rate of around 79%. As of 2019 Bangladesh has installed 21,419 MW. Bangladesh will need an estimated 34,000 MW of power by 2030 to sustain its economic growth of over 7 percent. The Bangladesh power sector has to face a lot of obstacle listing a very high system loss, more time to complete the proposed project, have no enough plant efficiency and most highlighted problem is shortage of enough fund. As of our population growth has a high rate and the demand of electricity is also getting high day by day. But actually, due to system or other reason we do not get that much electricity as our need [23].

3.2 Wind & Wind Energy

According to our geographical situation we get a high rate of wind in southern part of our country. We take Kutubdiya as a reference and collected some information to observe how they access electricity. Normally in this area electricity is generated from diesel and some people use their own solar PV. There are Winds Battery Hybrid Power Plant, which can supply more than 235 MW electrical energy over the local area. This power plant has some problem in case of the wind turbines measurement, distance between themselves, and blowing of wind. According to the potentiality of wind speed the mean value of wind speed is around 5.5 m/s in this coastal area [26]. Some data are shown below:

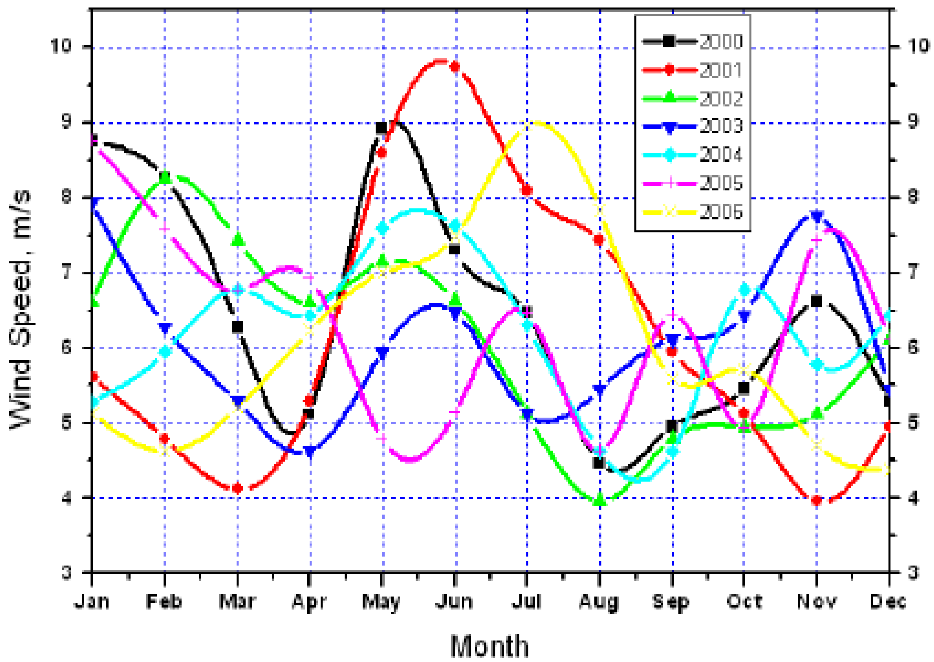

Figure3.1: Monthly wind variation in Kutubdiya (2000-2006)

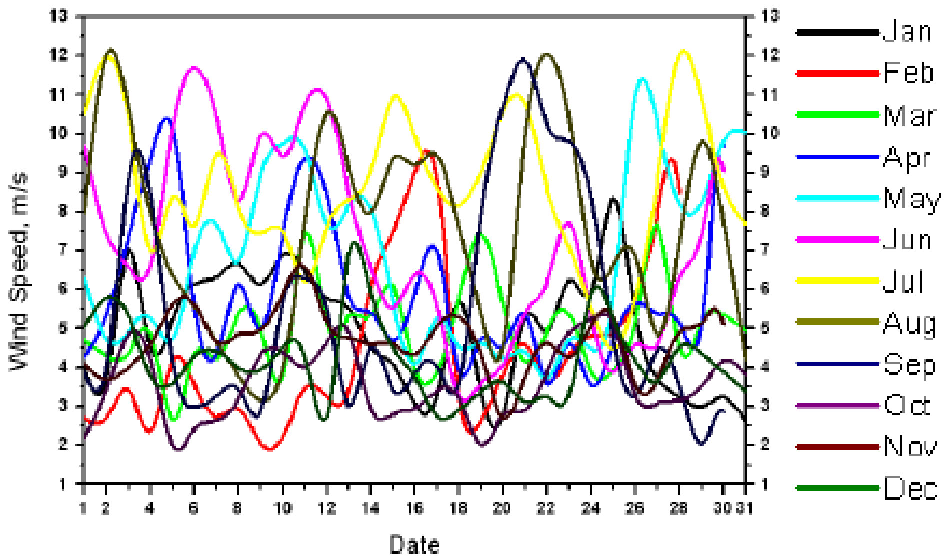

Figure 3.2: Daily wind variation in Kutubdiya (2006)

3.3 Analysis of Consuming Power Due to Wind speed

According to geographical structure the windiest area is the southern part of Bangladesh.

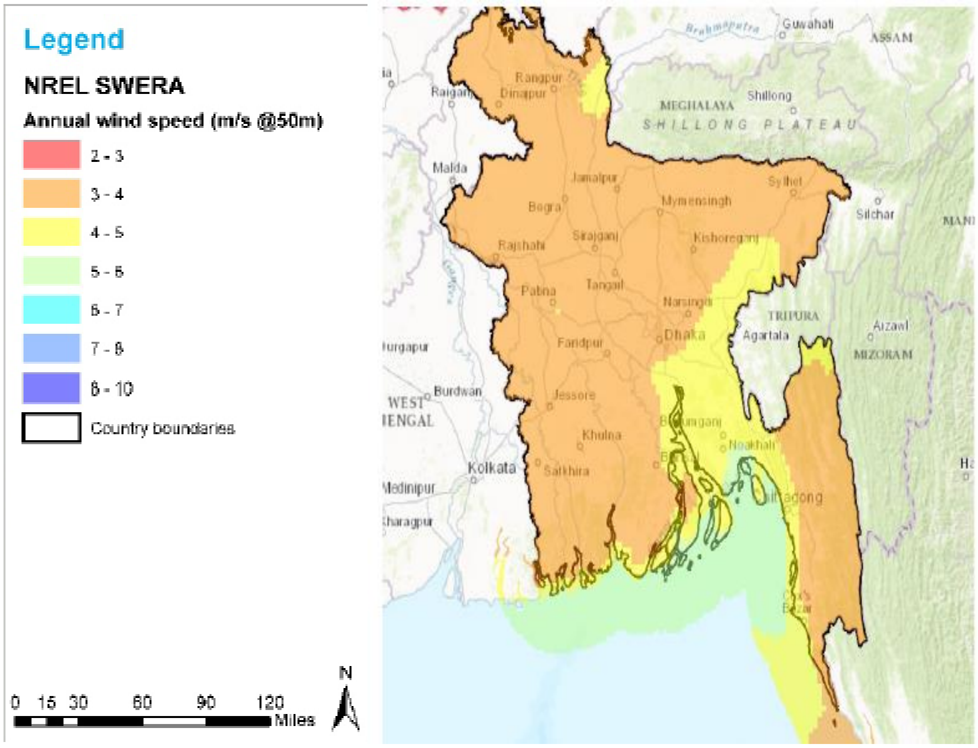

Figure 3.3: Wind speed in Bangladesh (Source NREL 2007 by Wind Minds)

3.4 Equation of Extractable Energy

Equation of Wind Energy P= $1/2 \times \rho \times V^3 \times C_p \times A$

Where,

A= Swept Area m^2

V= Wind speed m/s

ρ is Air density

C_p = Co efficient performance of Wind Turbine

Usually, C_p= 0.4

Transmission loss= 0.9

Generator Loss = 0.85

So Total Loss= 0.4$\times$0.9$\times$0.84

= 0.3024

Now, Power = 0.3024$\times$1/2$\times$ρ$\times V^3 \times$A

3.5 Daily Energy Consuming During Peak & Off Season

Summer and monsoons are considered as the peak season during this period of time we usually get higher rate of wind speed. From January-May it is considered as the off season. During this period of time usually the rate of wind speed is getting low. Feni one of the coastal areas of Bangladesh has different rate of wind speed in different season. As wind speed is much related to get high rate of energy, we get some data of a day at Feni in 2018 in both peak season and off season [27].

3.5.1 Power Generation Data of Peak Season

Table 3.1: Daily energy calculation of a day during peak season

Hour of a Day	Mean speed Of wind	Power(kW)	Power(kVA) at pf 0.8
1	7.18	53.37487937	66.71859922
2	7.12	52.04794113	65.05992641
3	7.21	54.04672317	67.55840396
4	7.28	55.63623229	69.54529037
5	7.64	64.30483816	80.3810477
6	7.34	57.02322211	71.27902763
7	7.2	53.82215258	67.27769073
8	7.36	57.49062325	71.86327906
9	7.45	59.62554917	74.53193646
10	7.28	55.63623229	69.54529037
11	6.92	47.78392908	59.72991135
12	6.81	45.54124609	56.92655762
13	6.85	46.34845783	57.93557229
14	7.01	49.67268406	62.09085507
15	6.94	48.19943919	60.24929899
16	6.76	44.54548191	55.68185238
17	6.63	42.02465521	52.53081902
18	6.77	44.74346154	55.92932692
19	6.78	44.94202691	56.17753363
20	6.81	45.54124609	56.92655762
21	6.64	42.21509898	52.76887373
22	6.64	42.21509898	52.76887373
23	6.86	46.55174025	58.18967531
24	7.11	51.82894587	64.78618234

From the data Table,

Power generated in a day is 1205.1619 kW

3.5.2 Graphical Analysis

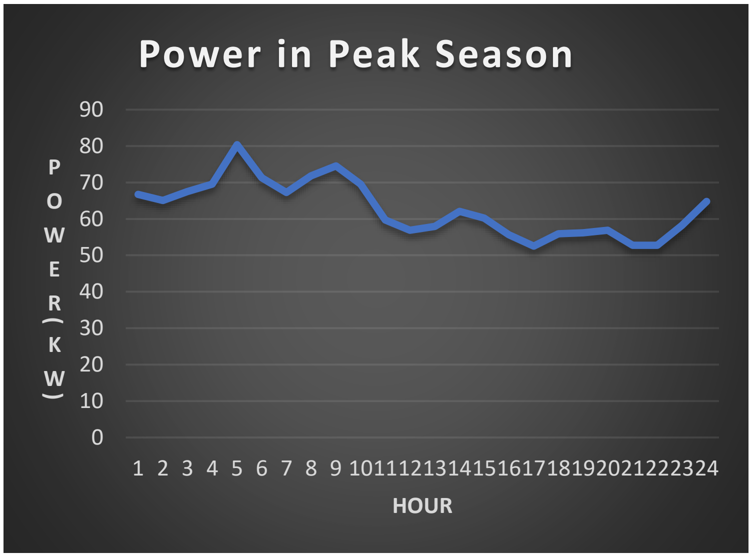

Figure 3.4: Power in a day during peak season

3.5.3 Power Generation Data of Off Season

Table 3.2: Daily energy calculation of a day during off season

Hour of a Day	Mean speed Of wind	Power(kW)	Power(kVA) at pf 0.8
1	4.38	12.11674325	15.14592906
2	4.13	10.15812912	12.6976614
3	3.28	5.088445237	6.360556547
4	2.87	3.408860774	4.261075968
5	2.97	3.777747456	4.72218432
6	2.97	3.777747456	4.72218432
7	3.16	4.550140653	5.687675816
8	3.22	4.814278265	6.017847832
9	3.3	5.182095275	6.477619094
10	3.42	5.768221009	7.210276261
11	3.41	5.717770383	7.147212979
12	3.55	6.451320721	8.064150902
13	4.15	10.30642065	12.88302581
14	4.59	13.94445774	17.43057217
15	5.25	20.86610959	26.08263699
16	5.36	22.20536636	27.75670795
17	5.27	21.10548903	26.38186128
18	5.07	18.79262518	23.49078147
19	4.89	16.86126489	21.07658111
20	4.74	15.3567247	19.19590588
21	4.82	16.14747752	20.1843469
22	4.79	15.84784132	19.80980165
23	4.53	13.40473337	16.75591671
24	4.57	13.76297034	17.20371293

From the data Table,

Power generated in a day is 269.4129 kW

3.5.4 Graphical Analysis

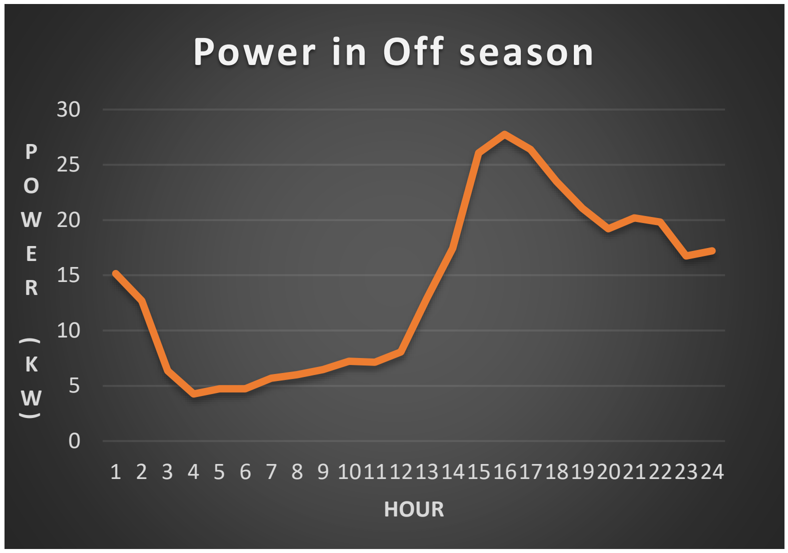

Figure 3.5: Power in a day during off season

3.6 Helix Turbine's Mathematical Calculation and Generation of Power

Usually for small scale wind turbine the dimension is used is 1 m length & 0.7 m diameter. To maximize the efficiency to generate power some formula is being used. By the Albert Betz calculation no wind turbine can convert more than 59.3% of kinetic energy of the wind into mechanical energy by rotating the Rotor. It is called Betz limitation [28].

For Helical turbine therefore the co-efficient performance of turbine, $C_p = 0.55$

The usual Tip ratio of Helical turbine is in between 2-2.5 in all resources. From this tip ratio value, we can measure the angular velocity ω. The relation is [1]

$$\lambda = \frac{r \times \omega}{V}$$

Here,

Tip Ratio= λ

Turbine radius = r

Angular velocity = ω

Wind Speed = V

Now From equation (2) we get

$$\omega = \frac{\lambda \times V}{r}$$

r= 0.7/2 = 0.35m

V = 7 m/s

Now the average value of λ is $\lambda_{avg} = \frac{2+2.5}{2}$ = 2.25

Therefore ω = 45 rad/s

Using the value of ω we can calculate the value of Torque of the Turbine by the following equation,

T = $\frac{(1/2 \times Cp \times \rho \times A \times V^3)}{\omega}$

Where,

Air density = ρ = 1.20 kg/m^2

Co-efficient of Power = Cp

Area = A = Length* Diameter = 1*0.7 = 0.7 m^2

Wind speed = V m/s

So,

T = 1.76 N.m

The Power of Turbine is

$P_{turbine} = 1/2 \times Cp \times \rho \times A \times V^3$ = 79.233 kW

3.6.1 Power Generation in Helical Turbine at Different Hour of a Day (Peak season)

Table 3.3: Daily energy calculation for Helical turbine of a day during peak season

Hour of a Day	Wind Speed	Area (m^2)	Power (kW)
1	7.18	0.7	85.50377959
2	7.12	0.7	83.37809357
3	7.21	0.7	86.58003839
4	7.28	0.7	89.12634931
5	7.64	0.7	103.0130049
6	7.34	0.7	91.34823482
7	7.2	0.7	86.220288
8	7.36	0.7	92.09698714
9	7.45	0.7	95.51702738
10	7.28	0.7	89.12634931
11	6.92	0.7	76.54736813
12	6.81	0.7	72.95470667
13	6.85	0.7	74.24781788
14	7.01	0.7	79.57305533
15	6.94	0.7	77.2129937
16	6.76	0.7	71.35954426
17	6.63	0.7	67.32131106
18	6.77	0.7	71.67669732
19	6.78	0.7	71.99478871
20	6.81	0.7	72.95470667
21	6.64	0.7	67.62639206
22	6.64	0.7	67.62639206
23	6.86	0.7	74.57346574
24	7.11	0.7	83.02727456

From the data Table,

Power generated in a day is 1930.60 kW

3.6.2: Graphical Analysis

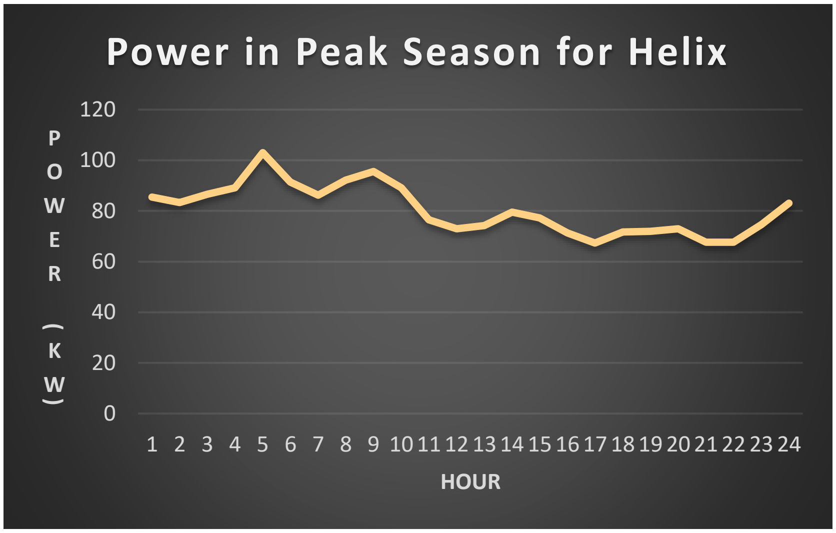

Figure 3.6: Power in a day during peak season for Helix turbine

3.6.3: Power Generation in Helical Turbine at Different Hour of a Day (Off season)

Table 3.4: Daily energy calculation for Helical turbine of a day during off season

Hour of a Day	Mean speed Of wind	Area (m^2)	Power (kW)
1	4.38	0.7	19.41039223
2	4.13	0.7	16.27279431
3	3.28	0.7	8.151424512
4	2.87	0.7	5.460817593
5	2.97	0.7	6.051754863
6	2.97	0.7	6.051754863
7	3.16	0.7	7.289088576
8	3.22	0.7	7.712223288
9	3.3	0.7	8.301447
10	3.42	0.7	9.240389928
11	3.41	0.7	9.159570651
12	3.55	0.7	10.33468013
13	4.15	0.7	16.51034963
14	4.59	0.7	22.33829575
15	5.25	0.7	33.42642188
16	5.36	0.7	35.57184154
17	5.27	0.7	33.80989527
18	5.07	0.7	30.10480773
19	4.89	0.7	27.01086904
20	4.74	0.7	24.60067394
21	4.82	0.7	25.86741881
22	4.79	0.7	25.38741721
23	4.53	0.7	21.47368539
24	4.57	0.7	22.04756238

From the data Table,

Power generated in a day is 431.58 kW

3.6.4: Graphical Analysis

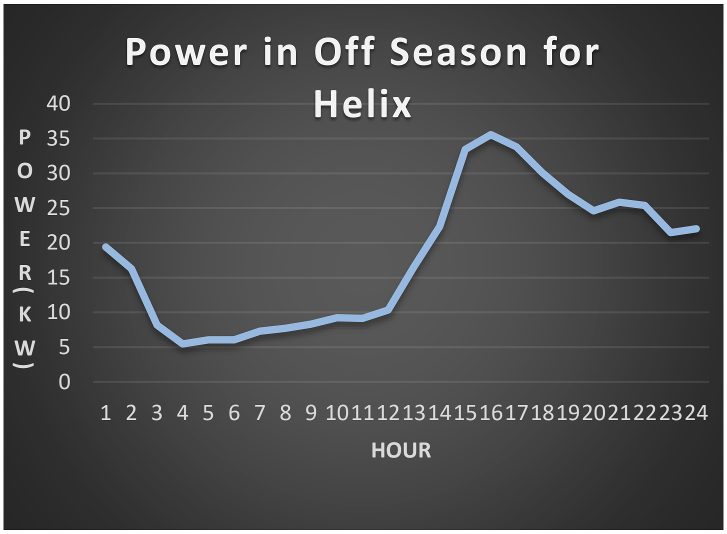

Figure 3.7: Power in a day during off season for Helix turbine

Chapter 4

Test Distribution System

4.1 Distribution

Here are few things we extract from the simulation.

1. Total loss
2. Line loss
3. Transformer loss
4. Load power loss percentage
5. Bus voltage kV value
6. Elements power

In the software part, we determined values for transformer, lines and loads. After simulation we can achieve the values for the parameters mentioned above.

As, we do not have the exact distribution diagram of load flow from Feni wind power plant, we are taking assuming distribution diagram. We can change values of these parameters as per our need.

The distribution diagram is provided below:

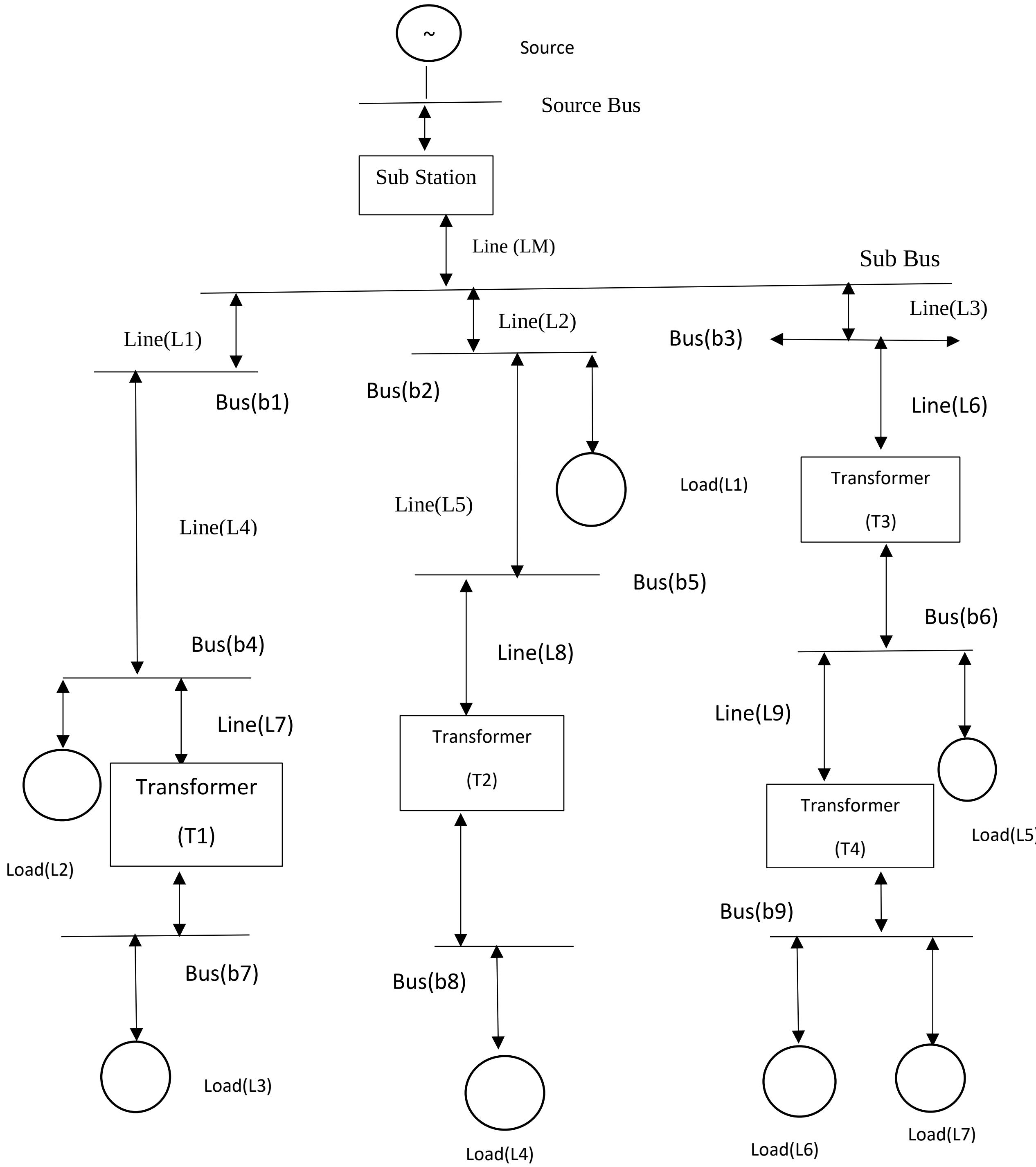

Figure 4.1: Distribution diagram

As per the diagram we have determined different parameters through assumptions. We can change them as per our need.

4.2 Line Definitions

New line.LM phase=4 bus1=sourcebus bus2=subbus length=.100 unit=km r1=0.06 x1=0.12

New line.L1 phase=4 bus1=subbus bus2=b1 length=20 unit=km r1=0.08 x1=0.15

New line.L2 phase=4 bus1=subbus bus2=b2 length=15 unit=km r1=0.09 x1=0.20

New line.L3 phase=4 bus1=subbus bus2=b3 length=15 unit=km r1=0.12 x1=0.09

New line.L4 phase=4 bus1=b1 bus2=b4 length=5 unit=km r1=0.15 x1=0.12

New line.L5 phase=4 bus1=b2 bus2=b5 length=12 unit=km r1=0.17 x1=0.25

New line.L6 phase=4 bus1=b3 bus2=b6 length=4 unit=km r1=0.15 x1=0.05

New line.L7 phase=4 bus1=b4 bus2=b7 length=8 unit=km r1=0.06 x1=0.12

New line.L8 phase=4 bus1=b5 bus2=b8 length=2 unit=km r1=0.08 x1=0.16

New line.L9 phase=4 bus1=b6 bus2=b9 length=.800 unit=km r1=0.12 x1=0.20

4.3 Load Definitions

New Load.Lo1 phase=3 bus1=b2 conn=wye kV=140 kW=70 KVAR=150 model=1

New Load.Lo2 phase=3 bus1=b4 conn=wye kV=90 kW=30 KVAR=150 model=2

New Load.Lo3 phase=3 bus1=b7 conn=delta kV=20 kW=10 KVAR=250 model=4

New Load.Lo4 phase=3 bus1=b8 conn=wye kV=30 kW=40 KVAR=150 model=3

New Load.Lo5 phase=3 bus1=b6 conn=wye kV=15 kW=.900 KVAR=200 model=1

New Load.Lo6 phase=3 bus1=b9 conn=wye kV=.440 kW=.500 KVAR=50 model=1

New Load.Lo7 phase=1 bus1=b9 conn=wye kV=.008 kW=.150 KVAR=20 model=1

4.4 Transformer Definitions

New transformer. Sub Phase=3 Windings=2 xhl=2 %loadloss=5 %noloadloss=0

~ wdg=1 bus=sourcebus conn=delta kV=50 kVA=62.76

~ wdg=2 bus=subbus conn=wye kV=132 kVA=62.76

New Transformer.T1 Phase=3 Windings=2 xhl=2 %loadloss=4 %noloadloss=2

~ wdg=1 bus=b4 conn=wye kV=132 kVA=62.76

~ wdg=2 bus=b7 conn=wye kV=60 kVA=62.76

New Transformer.T2 Phase=3 Windings=2 xhl=2 %loadloss=5 %noloadloss=0

~ wdg=1 bus=b5 conn=wye kV=132 kVA=62.76

~ wdg=2 bus=b8 conn=wye kV=40 kVA=62.76

New Transformer.T3 Phase=3 Windings=2 xhl=5 %loadloss=6 %noloadloss=2

~ wdg=1 bus=b3 conn=wye kV=132 kVA=62.76

~ wdg=2 bus=b6 conn=wye kV=11 kVA=62.76

New Transformer.T4 Phase=3 Windings=2 xhl=2 %loadloss=2 %noloadloss=0

~ wdg=1 bus=b6 conn=wye kV=11 kVA=62.76

~ wdg=2 bus=b9 conn=wye kV=0.22 kVA=62.76

4.5 Master Class

clear

New Circuit.Final

Redirect Linee.txt

Redirect loadd.txt

Redirect transformer.txt

Set Voltagebases=[100, 80]

solve maxcontrol=100

Calcvoltagebases

4.6 Simulation Code for Matlab

```
clc
clear all;
close all;
DSSObj = actxserver ('OpenDssEngine.Dss');
if ~DSSObj.Start(0),
    disp('Sorry');
    return
end
DSSText = DSSObj.Text;
DSSCircuit = DSSObj.ActiveCircuit;
DSSText.Command='Compile (E:\Study Material\THESIS\MATLAB\Final\Master.txt)'
DSSText.Command='Set mode=snapshot';
DSSText.Command='solve';
DSSText.Command='Show Losses';
DSSText.Command='Show Power';
DSSText.Command='Show voltages';
```

4.7 Results

We have simulated the codes given above. After the simulation the value we have found is provided in the following attachments.

Final_VLN.Txt - Notepad

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SYMMETRICAL COMPONENT VOLTAGES BY BUS (for 3-phase buses)

Bus	Mag: V1 (kV)	p.u.	V2 (kV)	%V2/V1	V0 (kV)	%V0/V1
sourcebus	22.17	0.4799	0.04785	0.2158	0.02905	0.1311
subbus	22.08	0.4781	0.04794	0.2171	0.02928	0.1326
b1	22.04	0.4771	0.04784	0.2171	0.02925	0.1327
b2	22.05	0.4774	0.04788	0.2171	0.0292	0.1324
b3	5.82	0.126	0.06157	1.058	0.06324	1.087
b4	22.03	0.4769	0.04782	0.2171	0.02924	0.1328
b5	22.02	0.4767	0.0478	0.2171	0.02914	0.1323
b6	1.502	0.03252	0.06474	4.31	0.07225	4.81
b7	22.01	0.4765	0.04779	0.2171	0.02923	0.1328
b8	22.01	0.4766	0.04779	0.2171	0.02912	0.1323
b9	0.1344	0.002909	0.0569	42.35	0.05709	42.49

Figure 4.2: Voltages for buses

Final_Power_seq_kVA.txt - Notepad

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SYMMETRICAL COMPONENT POWERS BY CIRCUIT ELEMENT (first 3 phases)

Element	Term	P1(kW)	Q1(kvar)	P2	Q2	P0	Q0	Excess Power			
								P_Norm	Q_Norm	P_Emerg	Q_Emerg
"Vsource.SOURCE"	1	-397664.0	-275438.5	0.3	1.0	0.1	0.4				
"Vsource.SOURCE"	2	0.0	0.0	0.0	0.0	0.0	0.0				
"Line.LM"	1	397185.9	275387.4	-0.3	-1.0	-0.1	-0.4	375361.3	260254.3	364449.3	252688.5
"Line.LM"	2	-396235.0	-273485.8	0.3	1.0	0.1	0.4				
"Line.L1"	1	191.1	867.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
"Line.L1"	2	-190.2	-902.8	-0.0	-0.0	-0.0	-0.0				
"Line.L2"	1	542.4	369.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
"Line.L2"	2	-542.0	-396.9	-0.0	-0.0	-0.0	-0.0				
"Line.L3"	1	395667.2	272175.2	-0.3	-1.0	-0.1	-0.4	373871.5	257181.1	362973.9	249684.7
"Line.L3"	2	-111831.0	-59313.1	0.5	1.2	0.4	0.9				
"Line.L4"	1	190.2	902.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
"Line.L4"	2	-189.7	-911.8	-0.0	-0.0	-0.0	-0.0				
"Line.L5"	1	536.8	385.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
"Line.L5"	2	-536.2	-407.2	-0.0	-0.0	-0.0	-0.0				
"Line.L6"	1	111841.7	59312.5	-0.5	-1.2	-0.3	-0.9	105680.6	56043.5	102600.5	54410.1
"Line.L6"	2	-17215.1	-27770.6	0.6	1.3	0.4	1.0				
"Line.L7"	1	310.0	947.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
"Line.L7"	2	-309.7	-961.9	-0.0	-0.0	-0.0	-0.0				
"Line.L8"	1	743.9	490.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
"Line.L8"	2	-743.8	-493.9	-0.0	-0.0	-0.0	-0.0				
"Line.L9"	1	17427.5	28108.2	6.0	5.9	6.6	7.4	16495.4	26598.2	16023.0	25836.5
"Line.L9"	2	-1915.3	-2254.5	-5.5	-5.0	-5.7	-5.4				
"Transformer.SUB"	1	478.1	51.1	0.0	0.0	0.0	0.0	425.4	45.5	406.3	43.4
"Transformer.SUB"	2	-165.7	73.9	-0.0	-0.0	0.0	0.0				
"Transformer.T1"	1	-125.7	-62.8	-0.0	-0.0	-0.0	-0.0	-107.8	-53.9	-101.4	-50.7
"Transformer.T1"	2	276.7	138.1	0.0	0.0	0.0	0.0				
"Transformer.T2"	1	-207.7	-83.1	-0.0	-0.0	-0.0	-0.0	-189.2	-75.7	-182.5	-73.0
"Transformer.T2"	2	685.2	274.1	0.0	0.0	0.0	0.0				
"Transformer.T3"	1	-10.7	0.6	-0.0	-0.0	-0.0	-0.0	-5.7	0.3	-3.9	0.2
"Transformer.T3"	2	29.7	15.1	0.1	0.0	0.1	0.1				
"Transformer.T4"	1	-242.1	-358.8	-6.7	-7.3	-7.1	-8.5	-249.6	-365.3	-247.3	-361.9
"Transformer.T4"	2	1309.1	1425.8	307.4	307.9	308.3	309.7				
"Load.L01"	1	5.2	11.2	0.0	0.0	0.0	0.0				
"Load.L02"	1	5.4	27.0	0.0	0.0	0.0	0.0				
"Load.L03"	1	33.0	823.8	0.0	0.0	-0.0	-0.0				
"Load.L04"	1	58.6	219.8	0.0	0.0	0.0	0.0				
"Load.L05"	1	0.0	6.0	0.0	0.0	0.0	0.0				
"Load.L06"	1	0.1	15.0	0.0	2.7	0.0	2.7				
"Load.L07"	1	0.0	0.0	0.0	0.0	0.0	0.0				

Total Circuit Losses = 397559.7 +j 274127.8

Figure 4.3: Powers of components

Final_Losses.Txt - Notepad

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```
LOSSES REPORT

Power Delivery Element Loss Report

Element                  kW Losses     % of Power    kvar Losses

"Line.LM"          950.86963,     0.24      1901.55
"Line.L1"            0.89836,     0.47      -35.7353
"Line.L2"            0.40753,     0.08      -27.1799
"Line.L3"       283836.65981,    71.74       212863
"Line.L4"            0.44264,     0.23      -8.97746
"Line.L5"            0.62331,     0.12      -21.4877
"Line.L6"        94626.80328,    84.61       31542.1
"Line.L7"            0.33257,     0.11      -14.2474
"Line.L8"            0.08753,     0.01      -3.55244
"Line.L9"        15513.63436,    88.95       25856.6
"Transformer.SUB" 312.37614,    65.34      124.95
"Transformer.T1"  151.07407,   120.23      75.2837
"Transformer.T2"  477.51392,   229.95      191.006
"Transformer.T3"   19.06707,   177.81      15.8305
"Transformer.T4" 1668.90533,   652.19      1668.91

LINE LOSSES=                    394930.8 kW
TRANSFORMER LOSSES=               2628.9 kW

TOTAL LOSSES=                   397559.7 kW

TOTAL LOAD POWER =                 104.1 kW
Percent Losses for Circuit =  381872.38 %
```

Figure 4.4: Losses of components

4.8 Comparison between Horizontal & Helix Turbine

Above we have some data of a day from Feni both Peak season and off season. We know at Feni there have used 4 wind turbines to generate power. From several reports it fails to generate expected power. Worldwide the horizontal turbines have some limitation where the Helix turbine has much advantage to use over Horizontal wind turbine.

There has some characteristic of Helix turbine which is much better choice for geographical situation and also generating power using the same wind speed.

1. **Spatial relation of the rotor:** Helix turbine is capable to pick wind from any direction. Unlike horizontal turbines has to depend on the same directional wind. Due to this difference Helix turbine can generate power in any situation whether the condition of climate is dully or good.
2. **Need less space:** In a Horizontal wind turbine power plant, the overall general guideline for dividing is to put the turbines 5 widths separated across the breeze, and around 10 breadths separated expanding downwind. This is to dodge disturbance of wind stream and decrease in wind speed brought about by one turbine to another, which influences the force yield of neighboring units. Contrasted with Horizontal wind turbines, Helix wind turbines can be assembled nearer in a breeze power plant. This is on the grounds that vertical pivot wind turbines work well in tempestuous breeze. They are by and large divided 4 to 6 diameters separated.

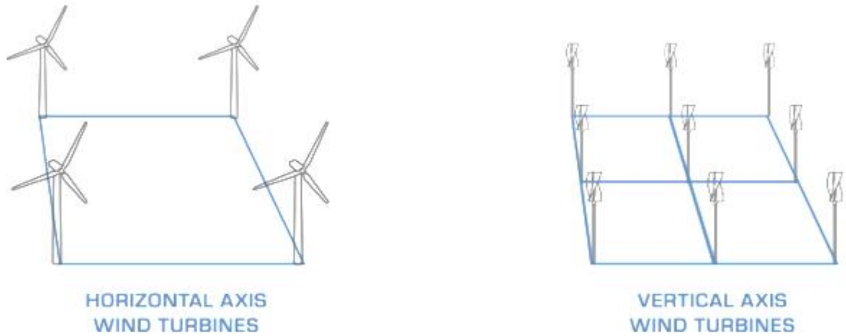

Figure 4.5: Spacing of Horizontal vs Vertical turbines

3. **<u>Starting wind speed has low rate:</u>** Comparing with the Horizontal wind turbine the Helix turbine has a lower rate of starting wind speed and the rate is about 2 to 3 m/s. It helps Helix turbine to generate electricity in lower speed of wind. The amount might be very small but still gets electricity.
4. **<u>Beneficial for environment:</u>** The size of Helix wind turbines brings along a couple of favorable circumstances, one of which being the low ecological mischief. Since they are fabricated intently around the shaft, the rotor cutting edges of Helix wind turbines don't make gigantic, expand drop shadows. The cutting edges are likewise simpler to spot for flying creatures and other flying creatures, diminishing the opportunity of creature casualty. Furthermore, Helix wind turbines work with calmer commotion emanation, so they don't upset individuals in private areas.

Chapter 5
Conclusion

5.1 Summary

There are altered varieties of wind turbines presented in the marketplace. Wind turbines can be categorized into diverse classifications. From an electrical idea of vision, wind turbines may be separated into two main collections, fixed-speed, and variable-speed operation. Both groups of wind turbines have advantages and disadvantages regarding the interface with the grid and the power quality. The main purpose is to decrease the cost as much as possible and creates more and more electrical energy. Helix can turbines can help to create more electrical energy than other turbines. As we know in our country electricity still is very far from many rural areas also, they cannot advantage of modern science. We also know that our country mostly covers by the river. It is very helpful to create powerful energy to electrical energy for reaching out the electricity all-over the country. But due to a lack of instruments, it becomes very impossible at a time. But now the country is improving and by using the Helix turbine the probability of increasing the rate of electricity will increase. On the other hand, the cost of the helix turbine is low than other turbines. So, like our country, the helix turbine can help to reach the electricity all over the rural places

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