STUDY & PERFORMANCE TEST OF A HORIZONTAL AXIS WIND TURBINE

SONARGAON UNIVERSITY (SU)

A Project & Thesis

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Table of Contents

LIST OF FIGURES

LIST OF TABLES

NOTATIONS

A	Cross-Sectional area of front view of the blade, m^2
ρ	Density of Air, kg/m^3
V	Velocity of Air, m/s
P_{wind}	Wind Power, watt
V	Voltage, volt
I	Current, amp
P	Power, watt

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ABSTRACT

The demand of electricity is increasing day by day, which cannot be fulfilled by only non-renewable energy sources. Bangladesh is a developing country. In 2041 Bangladesh will be developed country which is the vision of Bangladesh government. For the development of country electricity is the major fact. After certain time non- renewable energy such as Coal, Natural gas, Oil etc. will be finished. Renewable energy is another option for producing electricity. Renewable energy sources such as solar & wind are available everywhere & environmentally favorable. For the availability of wind; also, to encourage domestic power generation specially in an organization which have taller building, in this research the wind power generation system has been chosen. This paper discusses about the fabrication & performance evaluation of a Horizontal Axis wind power generation system by varying the wind velocity.

CHAPTER 1
INTRODUCTION

1.1 Background

In the present world, every country is giving important place on energy security and sustainable development; hence role of renewable energy has become ever more significant. With the expectation of promoting electricity generation based on non- conventional renewable energy, the government of Bangladesh introduced an energy policy to achieve a 5% target of power generation through non-conventional renewable energy by year 2015 and 10% by 2025. Bangladesh has set an ambitious goal of generating more than 4,100 megawatts of electricity from renewable energy sources by 2030 as the county looks to cut greenhouse gas emissions significantly. [1]

To achieve this target, government of Bangladesh is looking for various options preferably Renewable Energy resources. Under the existing generation scenario of Bangladesh, Renewable Energy has a very small share to the total generation. The share of Renewable Energy exceeds more than 3.5% till now. The present Government is placing priority on developing Renewable Energy resources to improve energy security and to establish a sustainable energy regime alongside of conventional energy sources. Government has already launched "500 MW Solar Power Mission" to promote the use of Renewable Energy to meet the increasing demand of electricity.[2]

Fig. 1.1 Map of Bangladesh. [3]

The People's Republic of Bangladesh is a developing country in the Bay of Bengal in South Asia, surrounded by India and Myanmar. Three large rivers run through this country; the Ganges, the Brahmaputra and the Meghna, together forming the Bengal Delta. With over 170 million inhabitants and a total surface of 147,570km2, Bangladesh is one of the most densely populated countries in the world with the two largest cities being the capital Dhaka and the harbour city of Chittagong.[4]

The utility electricity sector in Bangladesh has one National Grid with an installed capacity of 15,379 MW as on February 2017. Bangladesh's energy sector is booming. Recently, Bangladesh started construction of 2.4 GW Rooppur N4uclear Power Plant expected to go into operation in 2023. But still the per capita energy consumption in Bangladesh is considered low. Bangladesh has small reserves of oil and coal, but very large natural gas resources. Commercial energy consumption is mostly natural gas (around 66%), followed by oil, hydropower and coal. Electricity is the major source of power for most of the country's economic activities. Bangladesh's total installed electricity generation capacity (including captive power) was 15,351 MW as of January 2017. As 2015 92% urban population and 67% rural population have the access to the electricity for their source of light. Average 77.9% population have the access to the electricity in Bangladesh. Problems in the Bangladesh's electric power sector include, high system losses, delays in completion of new plants, low plant efficiency, erratic power supply, electricity theft, blackouts, and shortages of funds for power plant maintenance. Overall, the country's generation plants have been unable to meet system demand over the past decade. on-commercial energy sources, such as wood fuel, and crop residues, are estimated to account for over half of the country's energy consumption. On 2 November 2014, electricity was restored after a day-long nationwide blackout. A transmission line from India had failed, which "led to a cascade of failures throughout the national power grid," and criticism of "old grid infrastructure and poor management." However, in a recent root-cause analysis report the investing team has clarified that fault was actually due to Lack in electricity management & poor Transmission & Distribution health infrastructure that caused the blackout.[5]

Ensuring energy security, energy resources used in the country in the future need to be diversified. Also, to ensure the continuity of supply, energy mix need to be rationalized considering important factors, such as economic cost, environmental impact, reliability of supplies and convenience to consumers.

The wind power generation is a system aimed at the production and utilization of the electrical energy stemming from more than one source, provided that at least one of them is renewable.

Through this thesis it is expected to give concern about development of the wind power generation systems where wind potential is high in Bangladesh.

Wind system has numerous advantages. One of the advantages is reliability, reliability is improved and the system energy service is enhanced. Other advantages are the stability and lower maintenance requirements, thus reducing downtime during repairs or routine maintenance. In addition to these, as well as being indigenous and free, renewable energy resources contribute to the reduction of pollution emissions.

1.2 Problem Identification & Inspiration

With the world oil crisis, dangers of overdependence on oil pushed for the development of alternative energy sources. Current international trend in electricity generation is to utilize renewable energy resources. Solar, wind, biomass, micro hydro systems can be seen as suitable alternatives to conventional power. With the expectation of promoting electricity generation based on non-conventional renewable energy, the Government of Bangladesh introduced an Energy Policy to achieve a 5% target of power generation through non-conventional renewable energy by year 2015 and 10% by 2025.[1]

So far, these vast renewable energy resources, wind and solar, are not sufficiently harnessed for electricity generation in Bangladesh. Thus, in this thesis a wind power generation system integrating the available solar and wind resources will be investigated in detail for a specific location. Although it is not possible to generate large amount of electricity by wind power system, but this research will focus on the feasibility of power generation at See beach. So, we choose wind power generation system.

1.3 Objective of the Thesis

The main objective of the thesis is to design, fabrication and assess the performance analysis of a wind power generation system at the see beach, Bangladesh.

Specific Objectives of this thesis are:

1. Model analysis by varying wind velocity.
2. From optimum design, actual wind turbine will be fabricated.
3. Performance analysis will be carried out for the wind power generation system.
4. Design & construct of wind flow measurement system.

1.4 Methodology

Initially, literature review was done to get better understanding about the energy situation and problems of energy sector in Bangladesh. Design consideration of wind power system and modelling are main concept. Hence related literature was studied. In order to identify wind in Bangladesh. Previous study was analyzed that has been carried out in. The following steps are performed during completing project:

1. At first a model of horizontal axis wind turbine will be constructed.
2. Some parametric experimental studies will be carried out to make it more efficient.
3. Several blade configurations will be experimented for improving efficiency of the turbine.
4. From these an optimum configuration will be investigated from which Wind Turbine will . be constructed
5. The setup of wind power generation system is shown in chapter 5.
6. Several instruments like Tachometer, Voltmeter, Ammeter and Anemometer are used to . evaluate the performance.

1.5 Literature Review

To get a better insight about the different energy resources, energy supply, wind and solar potential in Bangladesh and hybrid power generation system, an elaborated literature study was carried out. Wind energy has been used for thousands of years for milling grain, pumping water and other mechanical power applications. Wind power is not a new concept. The first accepted establishment of the use of windmills was in the 10th century in Persia. New ways of using the energy of the wind eventually spread around the world. By the 11th century, people in the Middle East used windmills extensively for food production. Returning merchants and crusaders carried this idea back to Europe. The Dutch refined the windmill and adapted it for draining lakes and marshes in the Rhine River Delta. When settlers took this technology to the New World in the late 19th century, they began using windmills to pump water for farms and ranches and later to generate electricity for homes and industry.[6]

Wind energy was the fastest growing energy technology in the 1990s, in terms of percentage of yearly growth of installed capacity per technology source. The growth of wind energy, however, is not evenly distributed around the world. By the end of 1999, around 69% of the worldwide wind energy capacity was installed in Europe, a further 19% in North America and 10% in Asia and the Pacific.[7]

With the recent rise in energy costs many people have been looking to alternative sources of energy. One of the greatest energy sources is sun which is readily available for the taking. We just need to be able to harness its power. Solar technology isn't new. Its history spans from the 7th Century B.C. to today. We started out concentrating the sun's heat with glass and mirrors to light fires. Today, we have everything from solar-powered buildings to solar-powered vehicles. In 7th Century B.C. "Magnifying glass used to concentrate sun's rays to make fire and to burn ants." In 1921 Albert Einstein wins the Nobel Prize for his theories explaining the photoelectric effect.[8]

1.6 Outline of the Project & Thesis

This thesis is organized in 6 chapters. General introduction about the thesis on "Design of wind power generation system" is described in Chapter 1. Besides problem statement and inspiration, objective of the study, methodology the literature review of the thesis is included. Chapter 2 covers introduction about energy sector of Bangladesh and problems of energy sector in Bangladesh. Chapter 3 and Chapter 4 Construction and design details of wind turbine 5Performance evaluation of wind power generation system. Chapter 6 presents the result& discussion of the thesis. Finally, in chapter 6conclusions and recommendations are described.

CHAPTER 2

ENERGY SECTOR IN BANGLADESH

2.1 Energy Resources

Bangladesh is satisfied with several forms of renewable energy resources. Some of them are used and developed to supply the energy requirement of the country. Others have the potential for development when the technologies become advanced and economically feasible for use. Following are the main renewable resources available in Bangladesh.

Hydro Power, Biogas or Biomass, Solar Power, Wind Power. Also, Obtainable of Tidal Power, Wave energy, Waste to electric energy, geothermal energy

In addition to the above indigenous renewable resources, the availability of petroleum within the country territory is being investigated.

Petroleum, Coal, Natural Gas, Nuclear Energy are the most common energy sources globally available for electricity supply purposes. However, In Bangladesh petroleum and nuclear energy are imported in large scale into the country as a source of energy while coal is founded very recently for electricity generation. The use of other energy sources is still being studied.

To combat the rapid growth in electricity demand, the government adopted a phased approach to power generation. A 6-12 months program to generate electricity through liquid fuel based rental and quick rental power plants was followed by a short term (18-24 months) option of liquid fuel based peaking plants. The role played in the short term by small IPPs, contingency plants, and quick rental plants gave necessary relief for the interim period of three to five years until large base-load projects and major plants can be installed and become operational. Natural gas is the main energy source of Bangladesh and the power generation sector is heavily dependent on that. In 2014 FY, 8,340 MW were generated using 337.4 BCF natural gas. According to the Power System Master Plan 2016, the gas production from the domestic gas field will reach its peak in 2017. The Government is trying to meet the growing demand of natural gas by importing LNGS. The projection of primary energy for Bangladesh is shown in Table 2.1. As can be seen from the table that coal will be used extensively for power generation in future.[9]

Table 2.1 Primary energy projection.

Energy Source	2014		2041	
	ktoe	share (%)	ktoe	share (%)
Natural Gas	207280	57	49783	38
Oil	6060	17	32162	25
Coal	1038	3	25401	20
Nuclear	-	-	12029	9
Renewable Energy	36	0.1	199	0.16
Biofuel and waste	8449	23	4089	3
Power Export	377	1	6027	5

2.1.1 Hydro Power

At present only 230 MW of hydro power is utilized in Karnaphuli, Rangamati hydro station, which the only hydro-electric power plant operated by BPDB. Micro hydro and mini hydro have limited potential in Bangladesh, with the exception of Chittagong and the Chittagong hill tracts. Hydropower assessments have identified some possible sites from 10 kW to 5 MW but no appreciable capacity has yet been installed.[10]

2.1.2 Bio gas or Biomass

The potential of biogas as a renewable energy source for Bangladesh is relatively well-documented. In 1997, GTZ's Bangladesh Country study of biogas stated: "The cattle dung available from 22 million cows and buffaloes million of the 8.5 million households who own 'bovines' have 3 to 4 cows, and a further million have more than 5 cows is nearly 0.22 million tons / day. Similarly, Islam et al. In 2008estimated that animal dung available from 24.48 million cattle and buffalo is nearly 0.186 million tons/day. One ton of dung can produce 37 m3 of biogas. Available cattle dung can therefore produce between 2.5 to 3.0 x 109 m3 of gas per year which is the energy equivalent of between 2.5 to 3 million tons of coal. In addition, Islam et al. Mention that a substantial amount of biogas can be produced from human and other animal excreta (particularly poultry), garbage and water hyacinth.' The 2006 SNV report outlines a number of other reasons why biogas is an attractive option for Bangladesh. According to BCAS, the Chinese fixed dome biogas plant has proven to be the 'most suitable for Bangladesh', and a local variant is the 'only design that is being applied in the country' now.[10]

2.1.3 Solar Power

Solar energy presents a huge, almost limitless resource of effectively free renewable energy. It is also the largest renewable resource that Bangladesh has access to with no major risks or uncertainties in technology readiness. Rooftops present an opportunity to avoid land use changes in rural areas and represent a wasted resource in urban areas. Daily average solar radiation varies between 3 and 6.5kWh m-2 day-1, with maximum radiation in March and April and the minimum in December and January.[10]

2.1.4 Wind Power

Electricity generated by wind turbines can feed to the central grid or be locally consumed using smallest and-alone wind turbines. Generation of electricity from wind energy becomes very much promising where speed and wind power density are sufficiently high. Wind power generating capacity growth accelerated to 31% in 2009 through the whole world, with capacity increasing by a record 38 GW to reach 160 GW by the end of 2009. This was the sixth consecutive year of accelerating growth, remarkable achievement in a year of global economic recession. Wind turbines for grid-connected systems are the most highly demanded on the market and the rate of capacity growth is 28% per year between 1999 and 2009.[10]

2.1.5 Tidal Power

The tides at Chittagong Division are predominantly semidiurnal with a large variation in range corresponding to the seasons, the maximum occurring during the south-west monsoon. In 1984, an attempt was made by mechanical engineering department of KUET to assess the feasibility of tidal energy in the coastal regions of Bangladesh, especially at Cox's Bazar and at the islands of Maheshkhali and Kutubdia. The average tidal range was found within 4-5 meter and the amplitude of the spring tide exceeds even 6 meters. From different calculations, it is anticipated that there are a number of suitable sites at Cox's Bazar, Maheshkhali, Kutubdia and other places where permanent basins with pumping arrangements might be constructed which would be a double operation scheme.[1]

2.1.6 Wave energy

Bangladesh has favorable conditions for wave energy especially during the period beginning from late March to early October. Waves generated in Bay of Bengal and a result of the south-western wind is significant. Maximum wave height of over 2 meters with an absolute maximum of 2.4 meter were recorded. The wave periods varied from 3 to 4 seconds for waves of about 0.5 meter and about 6 seconds for waves of about 2 meters.[1]

2.1.7 Waste to electric energy

In order to save the large cities from environment pollution, the waste management as well as electricity generation from the solid wastes programmed is being taken by the government.[1]

2.1.8 Geothermal energy

Geothermal potential of Bangladesh is yet to be determined. Different studies carried out by geologists have suggested possible geothermal resources in the northwest and southeast region. Among the studied areas of northwest region, Singra-Kuchma- Bogra area, Barapukuria coal basin area, and the Madhyapara hard rock mine area - with temperature gradient above 30°C/km and bottom hole temperature in excess of 100°C-meet the requirements of binary cycle power plants. But to reach a foregone conclusion on exploiting the resource in a viable, feasible and economically profitable way, extensive research is required. In 2011, Anglo MGH Energy, a Dhaka-based private company announced the construction of 200 MW geothermal plant, first ever of such kind, in Thakurgaon district. But for some unknown reasons, this project never commenced, and no development in this field has been announced afterwards.[1]

2.2 Production of Electricity

Demand for electricity in Bangladesh is projected to reach 34,000 megawatts (MW) by 2030 and the Government of Bangladesh has plans to increase power generation beyond expected demand to help propel growth in the export-oriented economy and to meet the demands of a growing middle class. Total investment in the sector over the next 15 years is estimated at $70.5 billion. While installed generation capacity is 25,700 MW as of June 2022, shortfalls exist due to poor distribution infrastructure and a mismatch between the types of energy plants and fuel mix available. Private power production units are approaching half of total installed capacity. Only two-thirds of Bangladesh's population is currently connected to the electricity grid. This indicates an untapped potential market of up to 60 million people connecting to the national grid in coming years as Bangladesh continues its growth trajectory. The fuel mix of Bangladesh's power plants is heavily based on natural gas. The Government of Bangladesh plans to reduce dependence on natural gas and move towards coal with plans to generate 50 percent of total electricity using coal-based power plants by 2030. Other solutions include importing electricity from neighboring countries, importing liquefied natural gas (LNG), and expanding use of renewable resources, including solar and wind.[11]

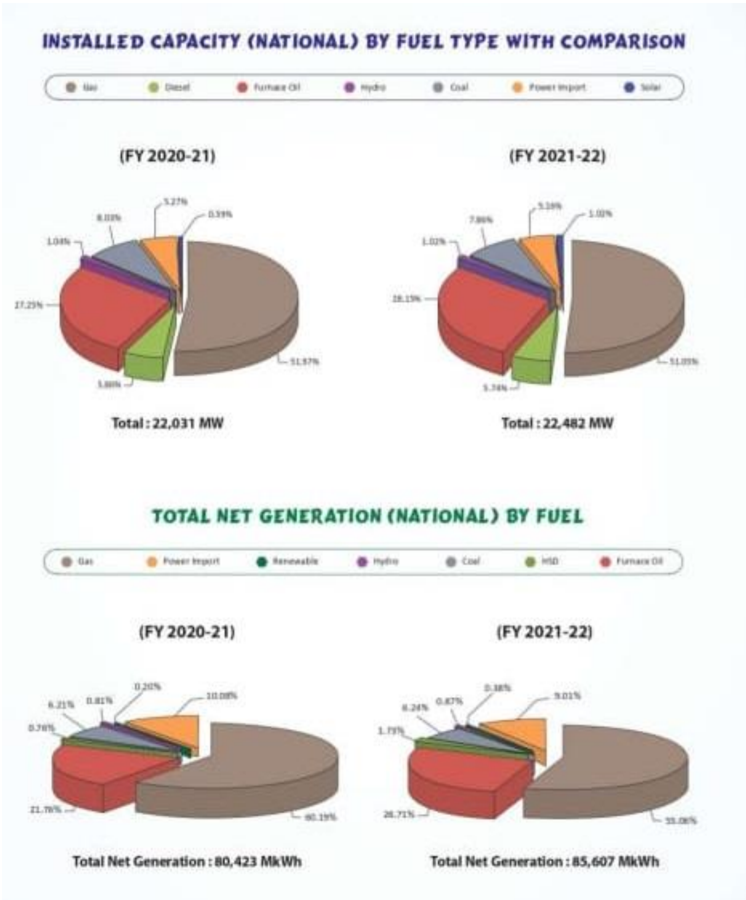

Fig. 2.1 Installed energy capacity in Bangladesh. [12]

CHAPTER 3

WIND ENERGY

3.1 Introduction

Wind energy is converted solar energy. The sun radiates energy on to the Earth and the Earth is heated unevenly. The atmosphere heats up much more quickly in the equator regions than in the rest of the globe. Lands heat up (and cool down) more quickly than the oceans do. This differential heating of the earth drives a global atmospheric convection system and resulting different air pressure fluctuations. Wind is the movement of air caused by pressure difference within the atmosphere. This pressure difference exerts a force that causes air mass to move from a region of high pressure to one of low pressure. That movement of air is referred to wind. Wind power is the transformation of wind energy into more utilizable forms, typically electricity using wind turbines.

3.2 History of the Wind Energy

Harnessing the wind is one of the oldest methods of generating energy. Since ancient times man has used the help of windmills to grind the harvest and to pump water. With the appearance of electricity at the end of the nineteenth century, the first prototypes of modern wind turbines were built, using technology based on the classical windmill. Since then, it has been a long process until wind energy was accepted as a serious and commercially sound method to generate energy. [13]

The oil crisis of the 70s, and even more the anti-nuclear power movement of the 80s, raised interest in alternative energies and the search for new ecologically and commercially viable ways of generating power intensified. The wind turbines built at that time were mainly for research, and extremely expensive. With the help of government financed international research and funding programs, as well as the creation of research institutes in the 80s, new methods of renewable power generation continued to be researched, developed and implemented. [13]

Research institutes such as the German Wind Energy Institute (DEWI) and the Danish Research Institute Risø, as well as various research programs and international co- operatives in the wind energy sector, were instrumental for the industrial and technological breakthroughs of professional wind energy pioneers. Thanks to close co-operation between the research institutes and the wind energy pioneers, international standards, strict regulation and increasingly efficient designs were developed and implemented to result in modern, commercially viable wind parks. [13]

With the development of the 55-kW wind power station in 1981, the early high costs of wind energy were dramatically reduced. Wind energy is now one of the cheapest energy sources when all external costs (e. g. environmental damage) are taken into account.[13]

Modern wind power stations increasingly generate a major proportion of global energy. Germany is one of the biggest wind energy markets, with the second largest amount of installed wind power capacity (23,903 MW in 2008) after the USA. Alongside Germany and the US, Spain, France, Denmark, China and India are the biggest users of wind energy to generate electricity. [13]

The wind energy industry, with its continuously growing export volume, has become an important global growth market and economic factor. [13]

3.3 Future of Wind Energy

International climate and environmental experts agree that the atmosphere of our planet is warming up and that we are running short of resources. Furthermore, all power stations built in the 60s or 70s will soon have to be replaced. Political and economic requirements have changed dramatically since those stations were built; global environmental problems can no longer be ignored. International environmental treaties, such as the Kyoto Protocol, establish legally binding commitments for the reduction of greenhouse gas concentrations in the atmosphere and industrialized countries agreed to reduce their collective GHG (greenhouse gas) emissions. International, standardized applications for renewable energies, regardless of national regulations or climate conditions, are more and more likely to be put into place. The wind energy industry's future looks optimistic. [13]

3.4 Wind power

Energy available in wind is basically the kinetic energy of large masses of air moving over the earth surface. Blades of the wind turbine receive this kinetic energy, which is then transformed to useful mechanical energy, which is then transformed further to mechanical or electrical energy depending on the end use.[13]

A wind rotor of cross-sectional area A in m2 is exposed to wind stream with velocity V in m/s as depicted in figure 3.1 below

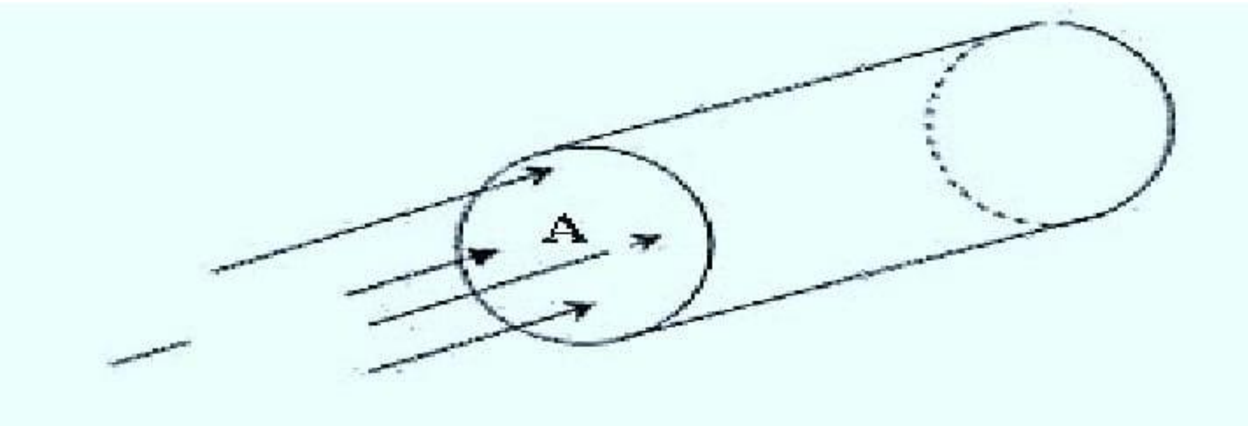

Fig. 3.1 Air moving with velocity V m/s towards area A m^2

Wind is air in motion. An air mass flowing through an area A(m^2) with a Velocity V(m/s) represents mass flow rate,

$$m = \rho AV \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Kinetic energy per second or the power possessed by moving air is, therefore,

$$P_{wind} = \frac{1}{2} mv \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Substituting for mass flow rate in the equation for power in the wind,

$$P_{wind} = \frac{1}{2} C\rho AV^3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

As shown in the equation above, the power of the wind is proportional to the cube of

the wind speeds.

The most accurate estimate for wind power density is given by following equation.

$$P = \frac{1}{2} A \quad \frac{1}{n} \quad \sum_{j=1}^{n} (PjV3j\ ) \ldots\ldots\ldots\ldots (4)$$

Where n is the number of wind speed reading and pjand V_j are the j_{th} reading of the air density and wind speed.

As shown in the equation output power is related to the area intercepting the wind, i.e. area swept by the wind turbine rotor. For horizontal axis turbine, the rotor swept area

is,

$$A = bh \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where, b and h are breath and height of the blade respectively in meters. Relatively small increases in blade length or breath produce a correspondingly bigger increase in the swept area, and therefore in power.

3.5 Wind Energy Scenario in Bangladesh

With its sub-tropical climate, with monsoon and typhoon seasons, Bangladesh is confronted with large amounts of rainfall and periodically high wind speeds (gusts) during typhoon season. The mean annual wind speeds in Bangladesh are not well documented and few data is available. The readily available data shows that low wind speeds predominate on the Bangladeshi lands. Next to onshore wind speeds, no(extensive) data is readily available concerning (far) offshore wind speeds.[14]

The 'Solar and Wind Energy Resources Assessment' initiative also calculated the annual wind speeds in Bangladesh, this at a height of 50 meter. The data is shown in figure 3.2. The maximum annual onshore wind speeds at 50 meters in Bangladesh do not outreach 5 meters per second, and 6 meters per second for offshore wind. These can be considered as low wind resources. During the typhoon season however, there can be wind gusts with speeds well over35 meters per second (>126 km/h).[14]

The international program Enhancing Capacity for Low-Emission Development Strategy (ECLEDS) is part of the USAID LEAD program, which supports and complements the US Government's Enhancing Capacity for Low Emission Development Strategies (EC-LEDS) initiative. EC-LEDS supports developing countries' efforts to pursue long-term, transformative development and accelerate sustainable, climate-resilient economic growth while slowing the growth of greenhouse gas emissions. Through this initiative, a current operational wind mapping project is funded. This project consists of 9 sites where a two-year wind speed metering programme is in progress at heights between 20 and 200 meters (with a met mast at 20, 40, 60 and 80 metres and two SODAR's up to 200 meters). See appendix F for a short description of the program. The preliminary results of the measurement campaign are still under embargo with the Ministry of Power. Final results of the measurement campaign are expected to become public in 2018. In appendix D a rough map of the wind resources of

Bangladesh is included to give an impression of the wind climate. Also, Vestas, a Danish wind turbine manufacturer, has been performing wind monitoring and site assessments in Bangladesh; these results are not made public.[14]

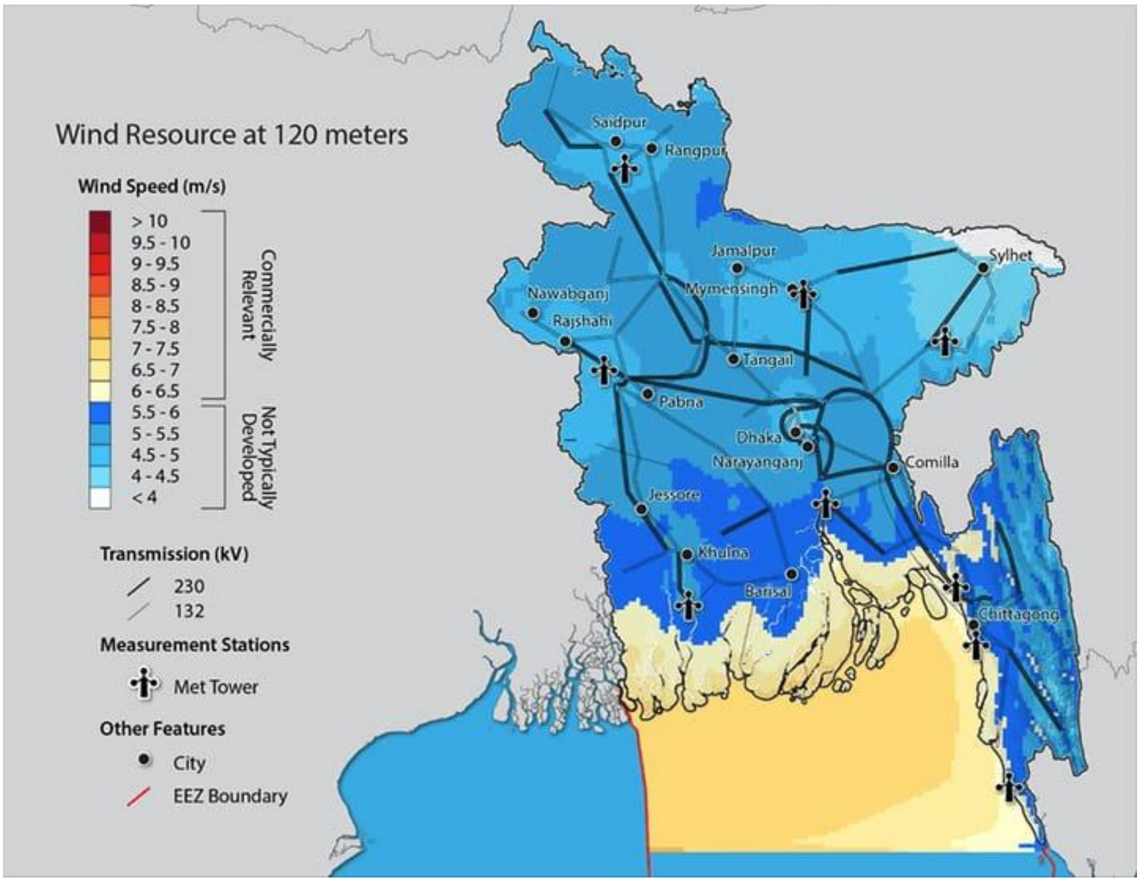

Fig. 3.2 Annual wind speeds in Bangladesh (Sourcce,2022)

3.6 Available space for wind farms

3.6.1 Onshore

Bangladesh is a densely populated country and being situated in the Bengal Delta, which makes large areas not usable for most activities, results in land being a scarce commodity. Figure 3.3 shows the land use of Bangladesh. As can be seen (light blue in the map), the vast majority of the country is used for agricultural purposes (maintained by irrigation processes).

Bangladesh consists mainly of flat lands. Three-quarters of the land has no elevation higher than 30 meters. The north and southeast are more elevated, in which the division of Chittagong is the most elevated land of the country (fig.3.4).[14]

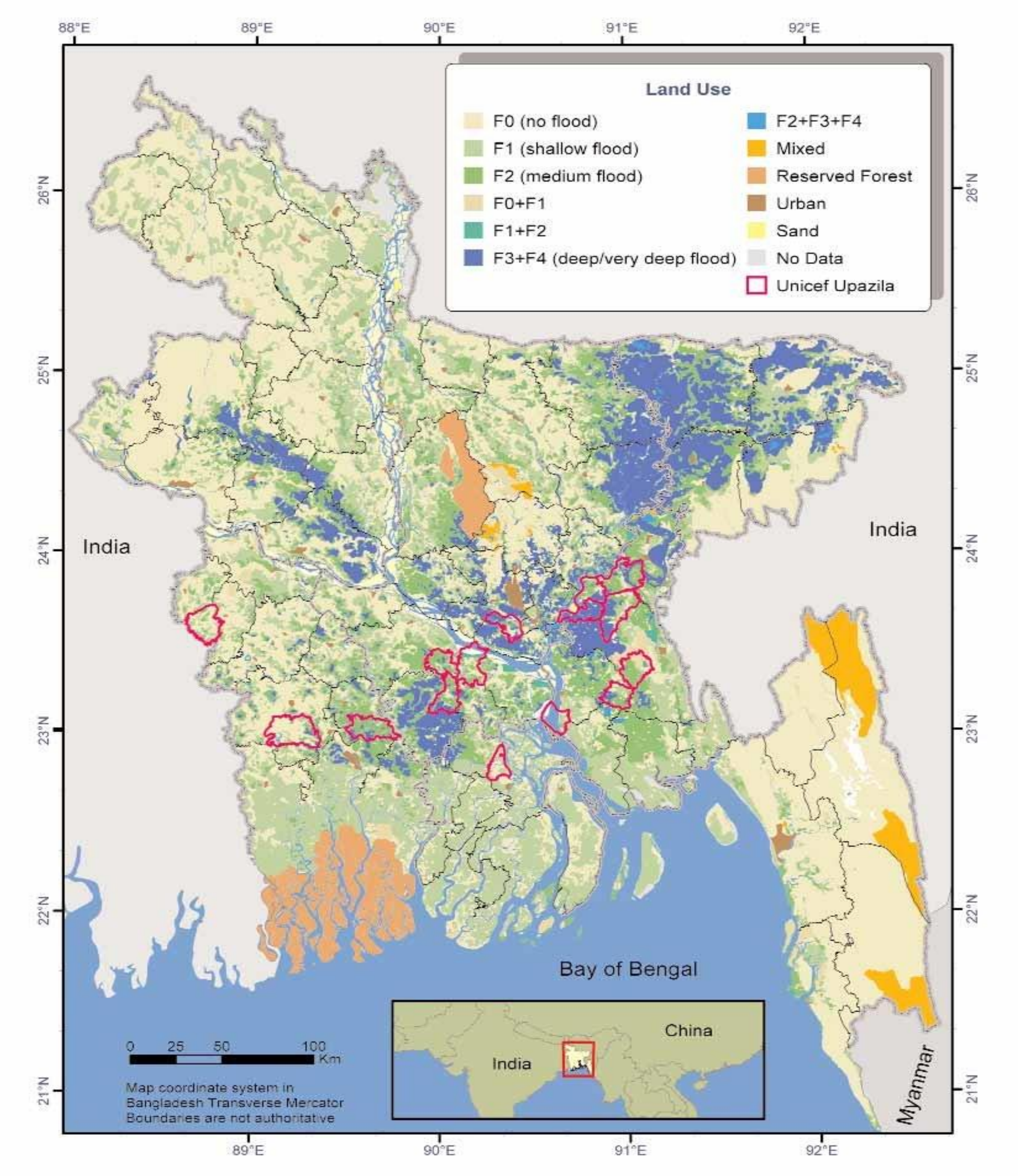

Fig. 3.3 Land use (Glob cover, 2022) [14]

3.6.2 Accessibility of the terrain

Are not well accessible with large trucks to transport

Large parts of Bangladesh modern wind turbine parts, due to infrastructure limitations. An advantage is however the presence of rivers that might be usable for transportation of heavy and large components.[14]

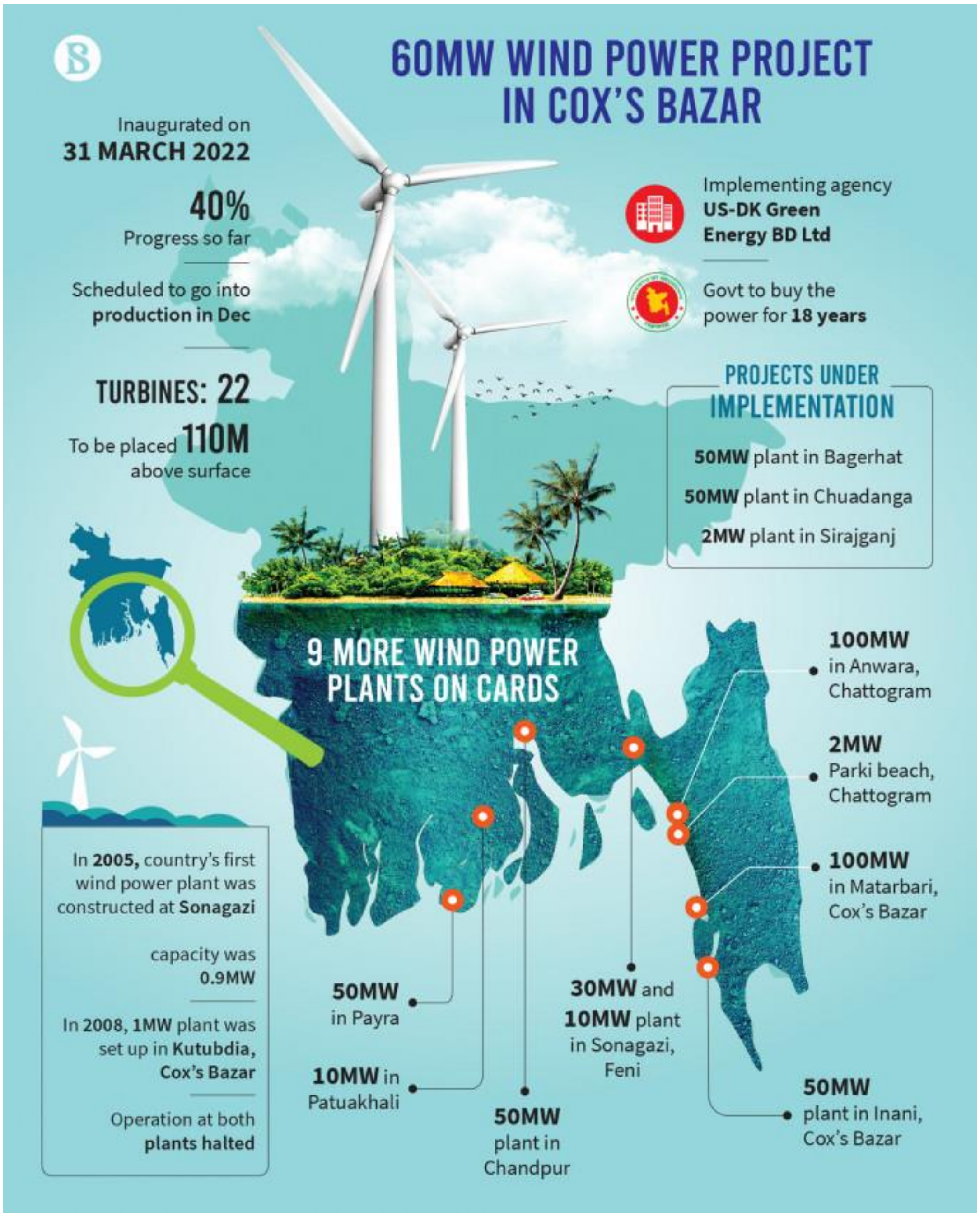

Fig. 3.4 60 MW wind power project

3.6.3 Offshore

With the active Ganges. the Brahmaputra and the Meghna rivers, fluvial components.[14]

Processes are current throughout the coastal line, with an exception off of the Chittagong coast. Partly by these processes, the first kilometers from the coast are

relatively shallow.

The 20-meter depth line is at its farthest ca. 110 kilometers from the coast of Patuakhali (see figure 3.5). Being fluvial sedimentation, it is anticipated that the soil of the seabed mainly consists of mud and loose sand. Offshore form the Chittagong division, the sedimentation processes seem to be of a lesser strength, but therefore the seabed is deeper, closer to shore. Next to this presumed solid seabed, the harbor of the City of Chittagong is also nearby, which can be a useful base for offshore contractors.[14]

CHAPTER 4

DESIGN & CONSTRUCTION

4.1 Introduction:

Wind power generation system is a one kind of mini power plant. It's a lower costing project which is long lasting or continuous duty cycle. Our project capacity is maximum 0.12-watt where charging duty cycle is 24 hours. Wind charging is effective in night because air velocity is high at night compared with day.

We design & construct a prototype system of wind turbine. The description given is below.

Fig. 4.1 Horizontal Axis Wind Turbine

4.2 Block Diagram:

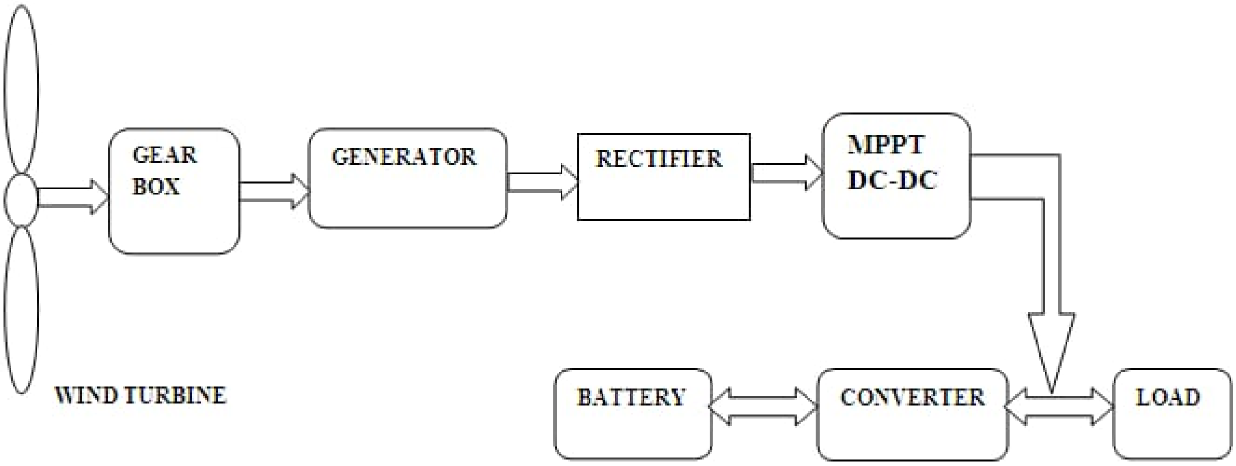

Fig. 4.2 Block Diagram

4.3 Circuit Diagram

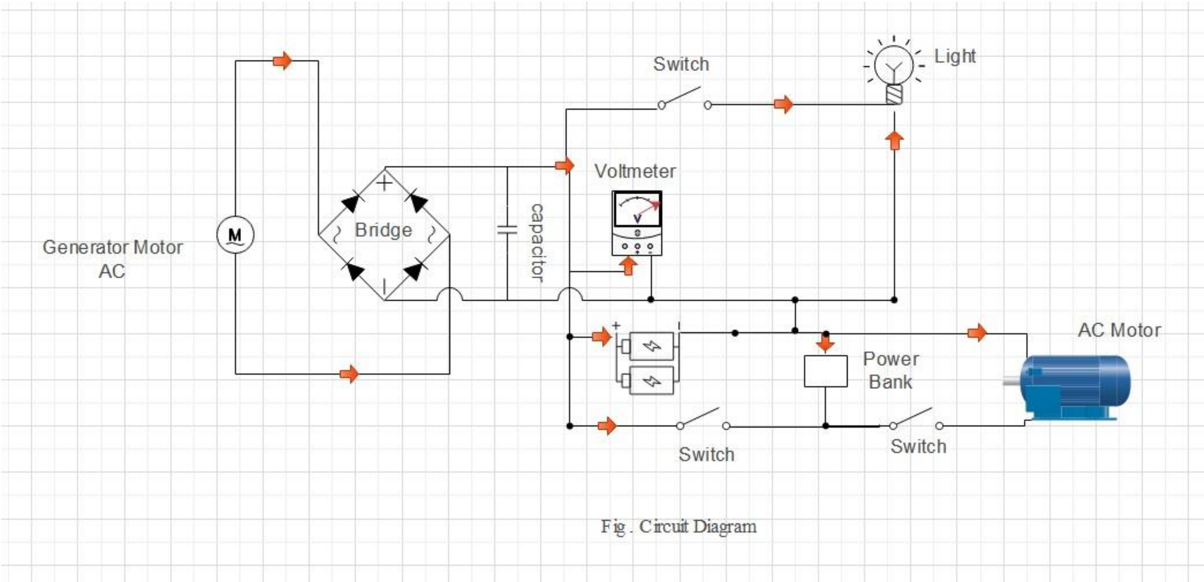

Fig. 4.3 Circuit Diagram

4.4 Required Instrument:

- Generator Motor.
- Wind Turbine.
- Volt Meter.
- Transformer.
- Rectifier.
- Battery

4.4.1. Generator Motor:

The most important reason is that it is cheaper than electric generators and it also contains many components we utilize in our daily lives. A motor is a device that converts electric energy into mechanical energy when electrified via its outputs; however, permanent Magnet DC motors can also have some adverse effects. The magnetic field created by the magnets causes a current to flow through a coil. You can see how electricity is produced in the below picture.

Fig. 4.4 Generator Motor

Permanent Magnet DC Motor Types for Generating Electricity

Permanent magnet DC motors are divided into two groups. The first is the permanent outer magnet and moving coil, while the second is the permanent coil and moving magnet.

Brushed DC Motor: These motors contain a permanent magnet and a moving coil within the magnet. The required electricity is produced by conveying the energy produced by the revolving brushes. Brushed DC motors are not the preferred method for producing electricity because the coil's, being in continuous motion, can have the following effects on the brushes:

a.) Degradation,

b.) Difficulty in producing electricity because of the brushes

You can see a brushed DC motor in the below;

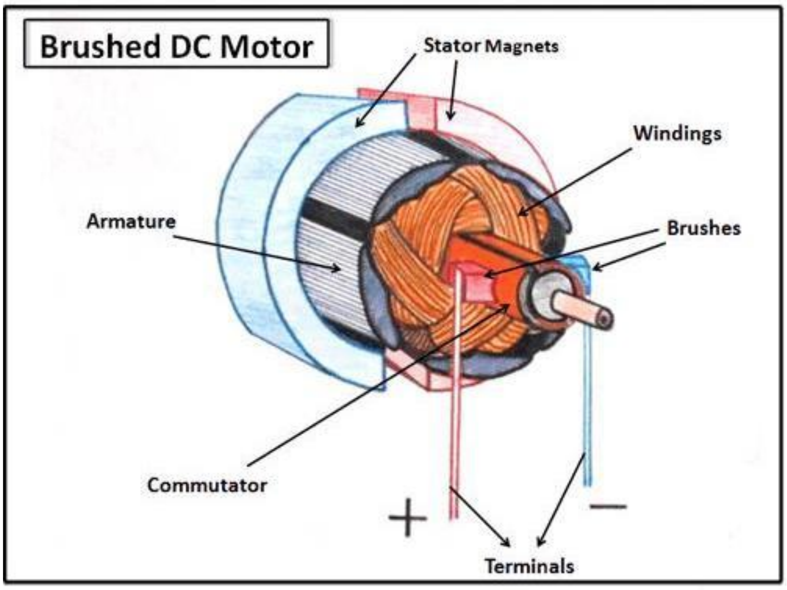

Fig. 4.5 Brushed DC Motor

Brushless DC Motor: These motors are the preferred choice of motors for producing electricity. Thanks to the moving magnet unit in the permanent coil, it easily produces electricity. Producing high efficiency and continuous electricity are the main features of brushless DC motors.

It is one of the most easily found motor types for those that want to build a wind generator at home. Wind energy is converted into rotation energy with the help of the blades installed on the edges of the motor and then converted into electricity with the help of the motor.

You can see images of the brushless DC motor below;

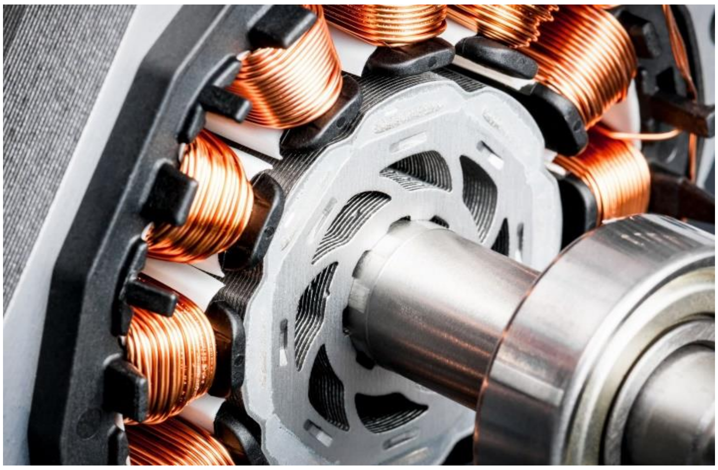

Fig. 4.6 Brushless DC Motor

Working Principle of Brushless DC Motor

As mentioned above a magnet with two poles is rotated around a permanent coil to produce electricity.

Detailed information is given in the below picture;

Best Motor Types to Build Wind Energy Turbine

Some types of motors are more efficient than others. With the same wind speed one can produce 10W whereas the other produces 40W.

1.) Treadmill Motors: These motors are both robust and efficient. This is our top recommendation for motors for producing electric energy. You can find them easily online or in stores selling second hand products. They cost between $20 and $250. Because of its values in relation to output current and output voltage, it can easily be used as wind turbine generator.

2.) Stepper Motors: Although highly efficient, stepper motors have a lower output voltage and current than treadmill motors. It can be used in wind systems that have a

lower power output.

3.) Standard Permanent Magnet Motor: These are for people who want produce electricity out of wind energy. They are cheaper than treadmill motors but some have higher HP levels. Sold for $20 - $1500, standard permanent magnet motors are our second choice for wind energy systems.

Fig. 4.7 AC Motors

AC Motors to Generate Electricity

The most important component for producing electricity with motors is the magnet. There are no magnets in AC motors and the energy needed for the motor is provided by AC voltage.

How to Choose the Right DC Motor?

The details you need to pay attention to before you choose a DC motor for producing electricity are:

Power Selection: It is hard to rotate motors with high power capacity, therefore the wind turbine blades should be chosen in accordance to the motor power. If the area you set up the wind turbine does not have enough wind, it would be wise to use motors with 1-3 HP power. If the wind speed is regularly 15 Mph and over, you should use 10 HP motors.

Power Requirement: It would be better if you used a turbine that is in accordance with the need of energy of that area. The selection of motor is also important; it should be consistent with the size of the turbine. For example, if you need 2000 Whirs of power, you will need to install a 2500 Whirs system.

Blade Design: Along with the wind speed, the design of blades, which divert wind energy into rotation energy, is important. For example, the rotating speed of a 3-blade system and a 6-blade system differ from each other. Because of this, the motor you choose to use has to be in harmony with the blade design.

Motor Power: If you need 1500W energy and you use a motor that produces less than that, you could damage your motor. You should, therefore, use motors that are 30% stronger.

4.4.2 Wind Turbine Motor Basic Calculations

The motor you choose should be built according to variables such as wind speed, blade design, blade number, and rotor diameter. These variables in detail:

Wind Speed: Is the amount of wind passing through a specific area. It is defined by variables such as mph (mile per hour), kph (kilometer per hour), and m/s (meters/second). The wind turbines used today start to rotate with 5 mph wind speed and work efficiently between 25 and 60 mph.

Blade Design: Although wind speed is the most important factor for rotation, the blades are the main components for converting wind energy into mechanical rotation energy. For this reason, the blade design is very important for efficiency.

Number of Blades: The number of blades influences the efficiency of the wind turbine. 2, 3, 5 blade wind turbines are frequently used. It is known that the more blades used, the more reliable and safer the wind turbine is. They work more silently and are more efficient. The cost is an adverse factor though.

Blade Efficiency: It related to the blade design part we mentioned above. The more efficient the blades, the more energy produced.

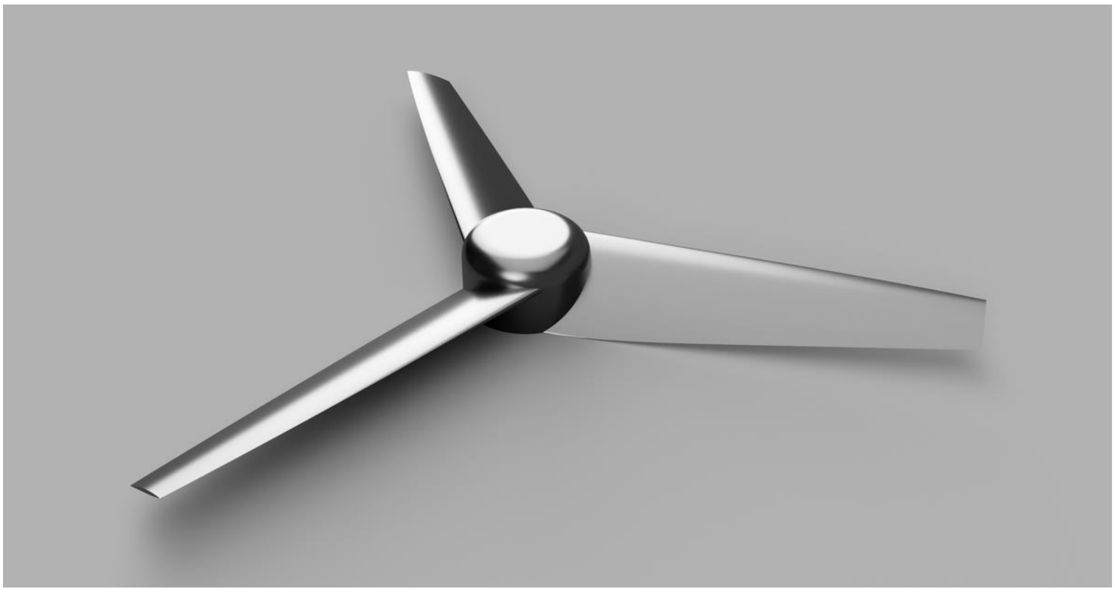

Fig. 4.8 Turbine Blades

Rotor Diameter: Meaning the turning diameter of the blades. More robust and big sized motors can be used in wind turbines with a high turning diameter.

TSR (tip speed ratio): If the wind turbines rotate too slowly, they lose much of the wind passing over them, and if they rotate too fast it is as though they act as a wall, meaning degradation occur. For this reason, optimum tip speed ratio is very important for efficiency. Some TSR ratios are;

- Blades: 9-10
- Blades: 6-8
- Blades: 4-6

Basic Calculations: The average wind speed in your region as well as maximum wind speed must be taken into consideration before building a wind turbine. Suggested figures are:

Average Wind Speed = 25 Mph = 11 m/s

Max Wind Speed = 70 Mph = 31.4 m/s

If the region where you will build a wind turbine has a value of wind speed between the values above, you should arrange the variables like blade size and number. If you want to have 2500 W/hours, the blade length should be 1 - 1.5 meter (3-5 feet). The designs with 3 blades can provide 35% - 40% efficiency so we suggest 3 blade

designs.

A motor which can generate 2500W power should have;

- 100A output current,

-25V output voltage,

Or;

-20A output current

- 125V output voltage.

For this motor to produce maximum power, it should rotate close to the maximum RPM it is intended for example, think that a 2500W motor's RPM value is 1200. To acquire 2500w power in the outputs of the motor we need 1200 rpm (revolutions per minute). The lower the rpm speed, the less the output power.

Basic Power Formula;

Blade length, 1 = x meter

Wind speed, v = x m/sec

Air density, ρ = 1.25kg/m^3

Efficient, C_p = average 0.3-0.4

$P_{total} = 0.5 (x) \rho (x) 3.14 (x) 12 (x) v^3 (x) C_p$

A motor-generator (an M-G set) is a device for converting electrical power to another form. Motor-generator sets are used to convert frequency, voltage, or phase of power. They may also be used to isolate electrical loads from the electrical power supply line. Large motor-generators were widely used to convert industrial amounts of power while smaller motor-generators (such as the one shown in the picture) were used to convert battery power to higher DC voltages. While a motor- generator set may consist of distinct motor and generator machines coupled together, a single unit dynamotor (for dynamo-motor) has the motor coils and the generator coils wound around a single rotor; both the motor and generator therefore share the same outer field coils or magnets.

Typically, the motor coils are driven from a commutator on one end of the shaft, while the generator coils provide output to another commutator on the other end of the shaft. The entire rotor and shaft assembly is smaller, lighter, and cheaper than a pair of machines, and does not require exposed drive shafts. Low-powered consumer devices such as vacuum tube vehicle radio receivers did not use expensive, noisy and bulky motor-generators. Instead, they used an inverter circuit consisting of a vibrator (a self-exciting relay) and a transformer to produce the higher voltages required for the vacuum tubes from the vehicle's 6 or 12V

battery.

The motor-generator set may contain a large flywheel to improve its ride-through; however, consideration must be taken in this application as the motor-generator will require a large amount of current on re-closure, if prior to the pull-out torquelclarification needed] is achieved, resulting in a shut down. The in-rush current during re-closure will depend on many factors, however. As an example, a 250 kVA motor generator operating at 300 ampere of full load current will require 1550 ampere of in-rush current during a re-closure after 5 seconds. This example used a fixed mounted flywheel sized to result in a 1/2 Hz per second slew rate. The motor-generator was a vertical type two-bearing machine with oil-bath bearings.

4.4.3 Transformer:

A transformer is an electrical device used to change the value of an alternating voltage. Transformers are widely used in electrical work. They are encountered daily, in industrial, commercial and domestic situations. They vary in size from miniature units used in electronics to huge units used in power stations. The efficient transmission and distribution of electricity throughout the country would be impossible without the use of power transformers.

Transformers are also used for safety reasons on construction sites when using power tools and in domestic bathroom situations in shaver units. They are used in doorbell operation and also to power electronic equipment, battery chargers, televisions, computers, alarm systems, etc. Transformers vary considerably in construction, size and shape depending on their application.

All transformers rely on the principle of mutual inductance for their operation. Mutual inductance was discussed in detail in Unit 2.1.6 Magnetism, Electromagnetism and Electromagnetic Induction.

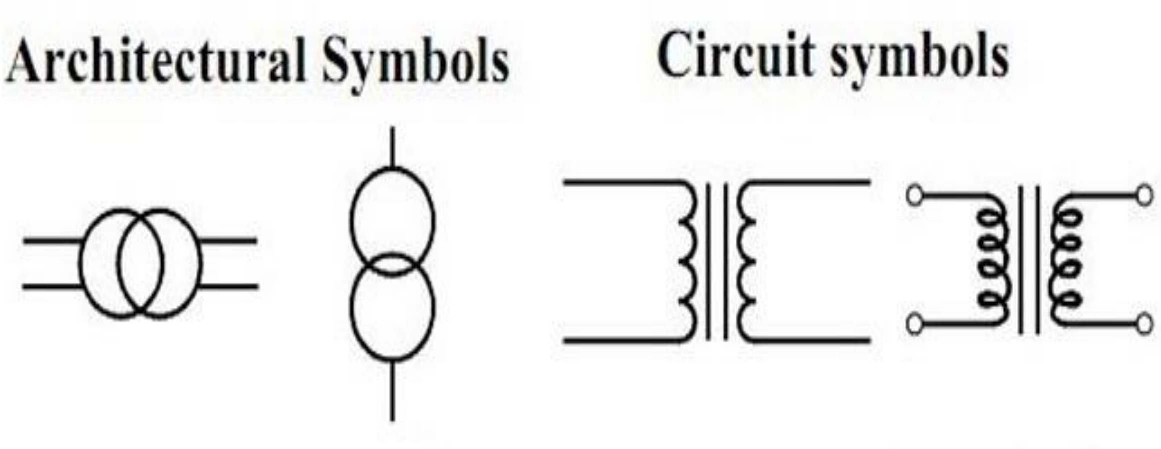

Fig. 4.9 Transformer Symbols

Transformer Construction:

A transformer consists of two coils of wire called windings, which are wound onto a common iron core. The wire used in the two windings, primary and secondary, is coated with an insulating varnish. Both coils are wound onto, but insulated from the iron core.

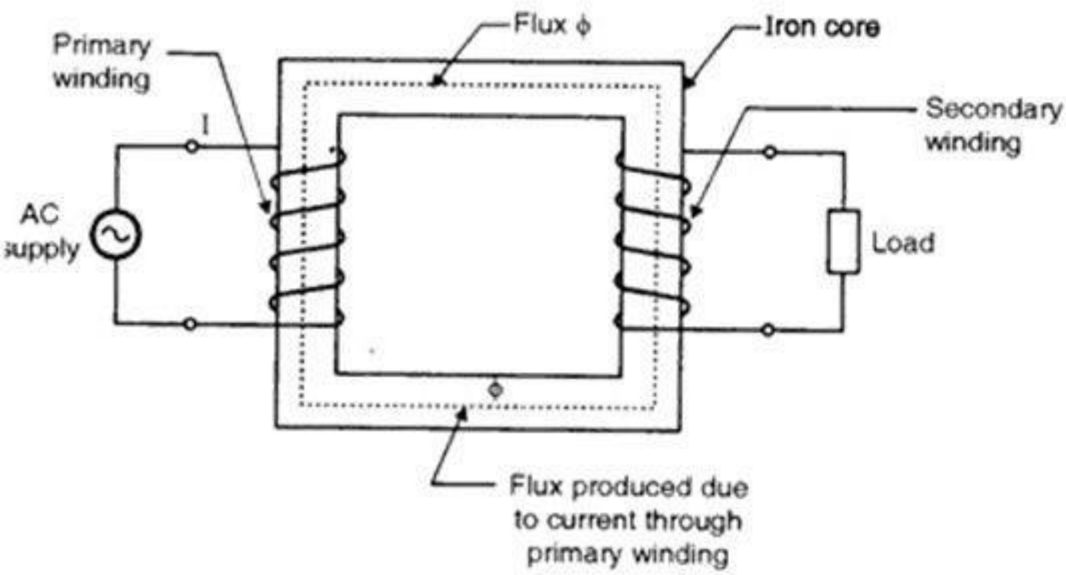

Fig. 4.10 Transformer Construction

The Transformer Principle:

When a conductor or coil is moved in a stationary magnetic field it cuts the lines of magnetic flux and an EMF is induced in the conductor or coil. This same principle also applies when a conductor is held stationary and the magnetic flux is made to change or vary.

Now consider an alternating current applied to a stationary coil. A magnetic field will build up and collapse in the coil, continually rising and falling in harmony with the applied AC current.

4.4.4 The Full Wave Rectifier:

The first building block in the dc power supply is the full wave rectifier. The purpose of the full wave rectifier (FWR) is to create a rectified ac output from a sinusoidal ac input signal. It does this by using the nonlinear conductivity characteristics of diodes to direct the path of the current.

Filtered Full Wave Rectifier:

The filtered full wave rectifier is created from the FWR by adding a capacitor across the output.

The result of the addition of a capacitor is a smoothing of the FWR output. The output is now a pulsating dc, with a peak-to-peak variation called ripple. The magnitude of the ripple depends on the input voltage magnitude and frequency, the filter capacitance, and the load resistance.

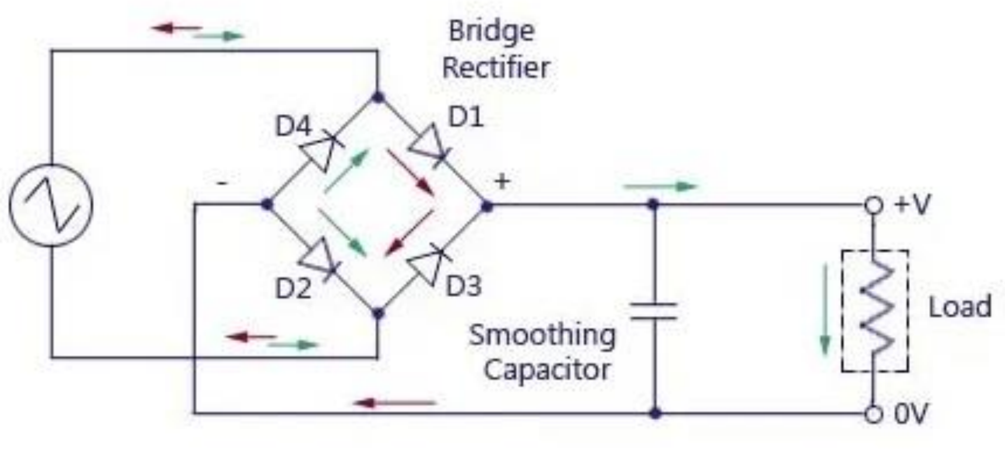

Fig. 4.11 Filtered full wave rectifier

To describe the source of the voltage ripple, consider the performance of the filtered full wave rectifier above. The input to the rectifier is a sine wave of frequency.

4.4.5 Battery

An improved wind turbine device with energy storage comprises a turbine rotor with rotatable vertical shaft, at least one bearing for said vertical shaft, and rotor vanes disposed moving symmetrically for rotation about the vertical shaft. Each of said flaps is capable of with the directional passage of wind through the vane. Battery is the most important part of energy storage. Here we using 1000mAh 4.2v Lithium ion battery. This is a backup storage, when the air flow will low but power is needed, that time we can use the storage capacity.

Fig 4.12 Lithium-ion battery

CHAPTER 5

PERFORMANCE ANALYSIS & DISCUSSION

5.1 Performance Analysis

From the experimentation result it was observed that the higher the wind speed the higher the power output will be, when the wind velocity is 1.6 m/s, power output 0.093 W but as the wind velocity increases to 1.7 m/s the power output will be 0.111 W. Due to gradually increasing wind velocity, the power output also increased. When wind speed was 2.5 m/s power output is 0.356 W when wind velocity was 3.4 m/s power output was 0.896 W and finally wind velocity was 39 m/s that time power output was 1.352 W. As shown in Table 5.1. Also shown in the fig. 5.1

WIND POWER:

Calculation

$P_{wind} = \frac{1}{2}\rho AV^3$

$=0.5*1.2*0.038*(3.9)^3$

$=1.35$ watt

Where,

$r = 0.11$ m

$\rho = 1.2$ kg/m^3

$A=\pi r^2$

$=\pi * 0.112$

$=0.038$ m^2

S/N	Wind Speed (m/s)	Wind Power (watt)
1.	3.9	1.352
2.	3.4	0.896
3.	2.5	0.356
4.	1.7	0.111
5.	1.6	0.093
6.	1.5	0.077

Table 5.1 Theoretical wind power with respect to wind speed

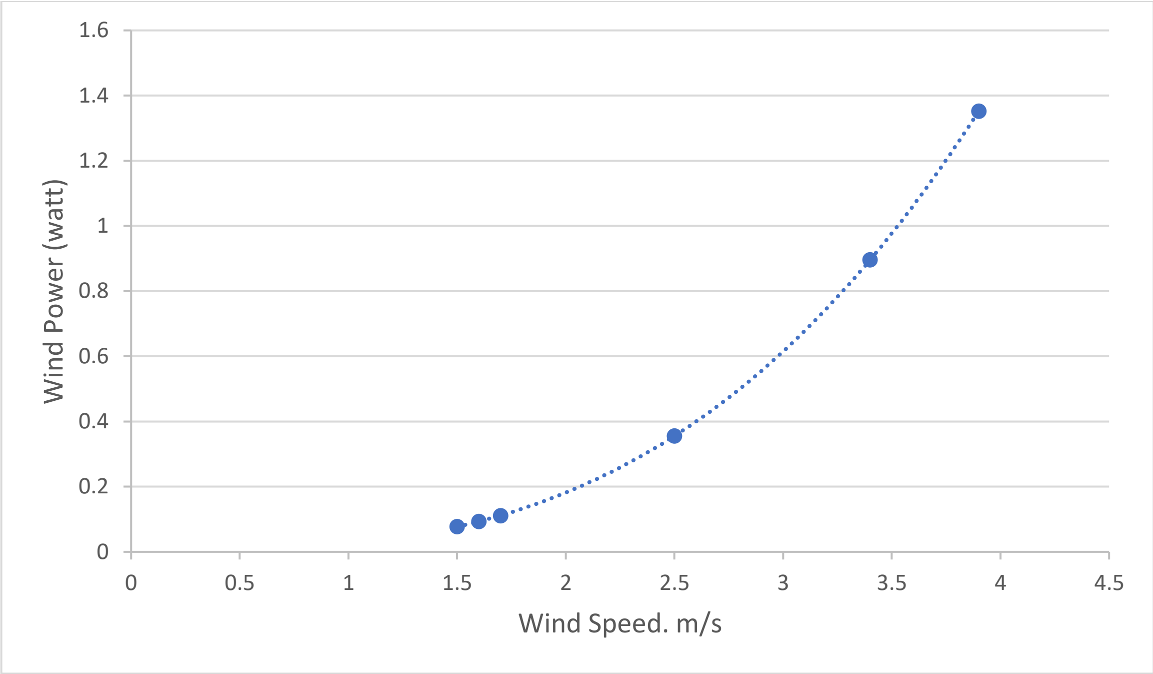

Fig. 5.1 Wind Speed vs wind power

GENERATOR POWER:

Calculations

The relation between current & voltage is

P=VI

= 5*0.03

= 0.15 watt

Where,

V = Voltage, volt

I = Current, amp

P = Power, watt

S/N	Voltage. volt	Current, Amp	Power, watt
1.	5	0.03	0.15
2.	4.15	0.02	0.083
3.	4.00	0.01	0.04
4.	2.70	0.01	0.027
5.	2.00	0.01	0.02
6.	1.90	0.01	0.019

Table 5.2 Generator Output

S/N	Wind Power (watt)	Generation Power (watt)
1.	1.352	0.15
2.	0.896	0.083
3.	0.356	0.04
4.	0.111	0.027
5.	0.093	0.02
6.	0.077	0.019

Table 5.3 Wind power vs generator power

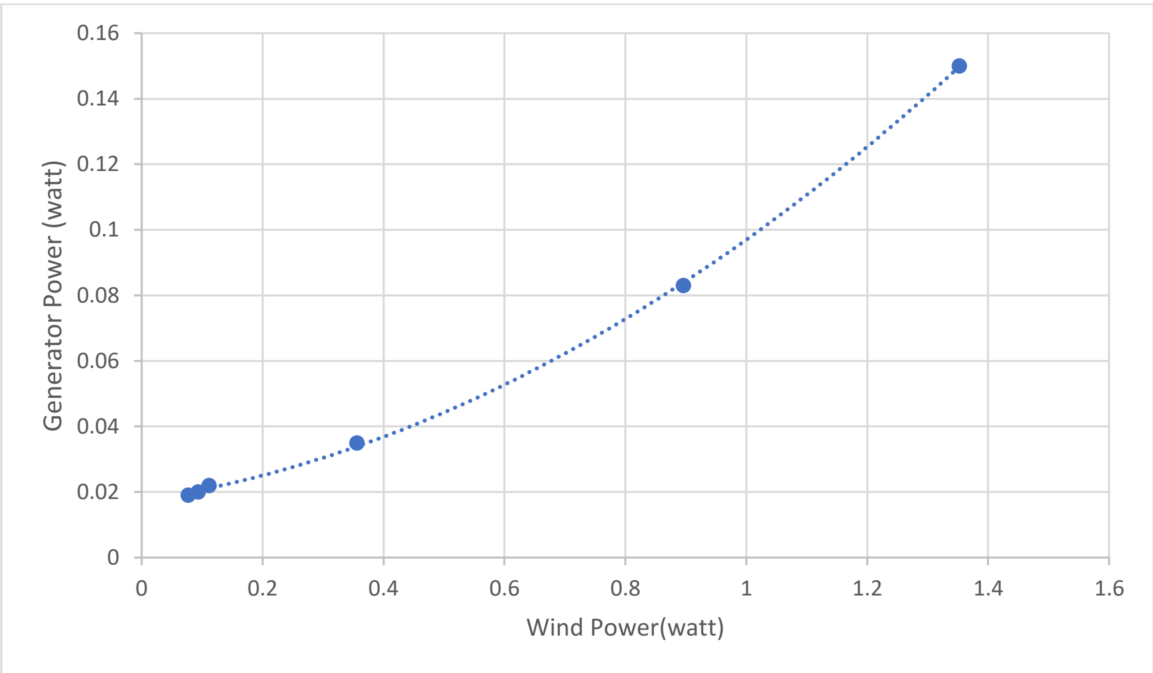

Fig. 5.2 Generator Power vs wind power

5.2 Discussion

From HAWT, we got different data for obtaining power which is the main objective of our project and thesis. From data in Table 5.1 we see that minimum power generation 0.077 watt and maximum power generation 1.352 watt. This power is theoretical power. We calculated this power from air velocity. Actually, it is not possible to supply power at a glance. Because air velocity is not constant and sometimes the air velocity is zero. When the air velocity is zero power produce also be zero. We found a reasonable air velocity for producing power in spring season. We think that our design is suitable for producing power which can be shown in Table 5.2

CHAPTER 6

CONCLUSION

6.1 Conclusion

Bangladesh is an over populated country. Every year the demand of energy is increasing with increasing population. But the source of energy is limited. There are many renewable sources of energy in our country. But the Wind is the easier are available source of renewable energy. Using wind and solar as a source of energy it is not possible to produce large amount of power but it can play a vital role in the present condition in relation to power shortage. Hence a Wind power generation system has been designed, fabricated and evaluates its various parameter.

6.2 Recommendation

Recommendation for further study, development of design and fabrication of the model:

1. Blade shape can be changed.
2. Blade angle can be changed.
3. Gear ratio can be changed to increase rpm.
4. The stability of the blade can be improved by using different material.

References

[1] *E. Renewable, "Renewable Energy in Bangladesh," Government of Bangladesh.* [Online]. Available: *http://www.powerdivision.gov.bd/user/brec/49/89.* [Accessed: 08-Feb-2022].

[2] E. Summary and B. Paper, "Development of renewable energy technologies and application," 2010 [Online]. Available: *http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=26&Itemid=24.* [Accessed: 08-Feb-2022].

[3] C. Environment, I. Arrangement, and M. Measures, "Map of Bangladesh," 1991.

[4] F. Affairs, "Baseline Study Wind Energy Bangladesh."

[5] F. Wikipedia, "Electricity_sector_in_Bangladesh." [Online]. Available: *https://en.wikipedia.org/wiki/Electricity_sector_in_Bangladesh.* [Accessed: 06-Feb-2018].

[6] M. Pasqualetti, R . Righter, and P. Gipe, "History of Wind Energy," Encyclopedia of Energy, 2004. [Online]. Available: *windenergyfoundation.org/about-wind-energy/history/.* [Accessed: 18-Jan-2022].

[7] T. Ackermann and L. Söder, "An overview of wind energy-status 2002," *Renew. Sustain. Energy Rev., vol. 6, no. 1-2, pp. 67-127, Jan. 2002*

[8] H. Z. A et al., "The history of solar," Sol. Energy Mater. Sol. Cells, vol. 93, pp. 1461-1470, 2011

[9] S. Islam and M. Z. R. Khan, "A Review of Energy Sector of Bangladesh, " *Energy Procedia*, vol. 110, no. December 2016, pp. 611-618, 2017.

[10] A. Hassan, M. S. Rahman, F. T. Khan, M. Bin Malik, and M. Z. Ali, "Electricity Challenge for Sustainable Future in Bangladesh," APCBEE *Procedia*, vol. 1, no. January, pp. 346-350, 2012.

[11] B. C. C. Guide, "Bangladesh - Power & Energy.," 2017. [Online]. Available: *https://www.export.gov/article?id=Bangladesh-Power-and-energy.* [Accessed: 07-Feb-2022].

[12] BPDB, "Power Generation Units (Fuel Type Wise)," 2015. [Online]. Available: *http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=150&Itemid=16.* [Accessed: 12-Feb-2022].

[13] A. P. Society, "Wind energy," Wind Energy, 2003. [Online]. Available: *http://link.springer.com/10.1007/978-3-540-33866-6*. [Accessed: 08-Feb-2022]

[14] G. Bekelea and G. Boneya, "Design of a photovoltaic-wind hybrid power generation system for Ethiopian remote area," Energy Procedia, vol. 14, pp. 1760-1765, 2012.