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College of graduate Studies

Using Wind Power as an Alternative Energy

استخدام قدرة مولدات الرياح طاقة بديلة

Thesis submitted in partial for requirement of the degree of master in physics

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بسم الله الرحمن الرحيم

﴿ وَمِنْ آيَاتِهِ أَن يُرْسِلَ الرِّيَاحَ مُبَشِّرَاتٍ وَلِيُذِيقَكُم مِّن رَّحْمَتِهِ وَلِتَجْرِيَ الْفُلْكُ

بِأَمْرِهِ وَلِتَبْتَغُوا مِن فَضْلِهِ وَلَعَلَّكُمْ تَشْكُرُونَ ﴾

صدق الله العظيم

سورة الروم الآية (46)

Dedication

I dedicate this thesis

To my parents whom always were beside me

To my husband

To my daughter

To my supervisor

To my university and my college

To my colleagues

Acknowledgment

Thanks before and after to Allah. I am very grateful to Dr. Sawsan Ahmed Elhouri who supervised this thesis. A lot of thanks are extending to my husband for his great help and kind guidance. Would like thank all the professors at department of physics in Sudan University of Science and Technology. Appreciation to all who helped me during this research.

Abstract

This study deals with wind energy, which is one of the most important types of renewable energies. As well as, studying and discussing wind energy applications, development and useful practices in generating electricity, pumping water, and implementation in addition to turbines designing. Then the mechanism of wind energy and the factors influencing the production of this great energy.

المستخلص

تتناول هذه الدراسة طاقة الرياح وهي واحده من اهم أنواع الطاقات المتجددة. ناقش البحث طاقة الرياح وتنميتها واستخداماتها المفيدة في توليد الكهرباء وضخ المياه واستخدام التوربينات وتصميمها ثم الية طاقة الرياح والعوامل المؤثرة في انتاج هذه الطاقة العظيمة.

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Chapter One
Introduction

1.1 Prelude

Wind is the movement of air from an area of high pressure to an area of low pressure. In fact, wind exists because the sun unevenly heats the surface of the Earth. As hot air rises, cooler air moves in to fill the void. As long as the sun shines, the wind will blow. And wind has long served as a power source to humans. Ancient mariners used sails to capture the wind. Farmers once used windmills to grind their grains and pump water. Today, more and more wind turbines wring electricity from the breeze.

Over the past decade, wind turbine use has increased more than 25 percent per year. Still, it only provides a small fraction of the world's energy. Wind power is the use of air flow through wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land.

1.2 Objectives of the Study

Knowledge of renewable energies, especially wind energy, and their use as an alternative source of electricity generation instead of fossil fuels, oil and natural gas because these sources are harmful sources of the environment.

1.3 Research Problem

*Uses of wind energy and their development.

*The different between Wind turbine and windmill.

*Types and design of wind turbine.

*The mechanism of wind energy.

*Factors Affecting of Wind Energy Production.

1.4 Literature Review

***Design and model confirmation of the intermediate scale volturn us floating wind turbine subjected to its extreme design conditions offshore Maine Done by Anthony M.viselli and etal.**

Floating offshore wind turbines are gaining considerable interest in the renewable energy sector. Design standards for floating offshore wind turbines such as the American Bureau of Shipping (ABS) Guide for Building and Classing Floating Offshore Wind Turbine Installations are relatively new and few if any floating winds turbines have yet experienced the prescribed design extreme environmental conditions. Only a few pilot floating turbines have been deployed in Europe and Japan. These turbines have been designed for long return period storm events and are not likely to see their extreme design conditions during early deployment periods because of the low probability of occurrence. This paper presents data collected for an intermediate scale floating semi-submersible turbine intentionally placed offshore Maine in a carefully selected site that subjects the prototype to scale extreme conditions on a frequent basis. This prototype, called VolturnUS 1:8, was the first grid-connected offshore wind turbine in the Americas, and is a 1:8 scale model of a 6 MW prototype. The test site produces with a high probability 1:8 scale wave environments, and a commercial turbine has been selected so that the wind environment/rotor combination produces 1:8-scale aerodynamic loads appropriate for the site wave environment. In the winter of 2013–2014, this prototype has seen the equivalent of 50 year to 500 year return period storms exercising it to the limits prescribed by design standards, offering a unique look at the behavior of a floating turbine subjected to extreme design conditions. Performance data are provided and compared to full-scale predicted values from numerical models. There are two objectives in presenting this data and associated analysis: (i) validate numerical aero elastic hydrodynamic coupled models and (ii) investigate the performance of a near full-scale floating wind turbine in a real offshore environment that closely matches the prescribed design conditions from the ABS Guide[1].

***Renewable Power-to-Gas: A technological and economic review**

Panel

Done by *ManuelGötz and etal*

The Power-to-Gas (PtG) process chain could play a significant role in the future energy system. Renewable electric energy can be transformed into storable methane via electrolysis and subsequent methanation. This article compares the available electrolysis and methanation technologies with respect to the stringent requirements of the PtG chain such as low CAPEX, high efficiency, and high flexibility.Three water electrolysis technologies are considered: alkaline electrolysis, PEM electrolysis, and solid oxide electrolysis. Alkaline electrolysis is currently the cheapest technology; however, in the future PEM electrolysis could be better suited for the PtG process chain. Solid oxide electrolysis could also be an option in future, especially if heat sources are available. Several different reactor concepts can be used for the methanation reaction. For catalytic methanation, typically fixed-bed reactors are used; however, novel reactor concepts such as three-phase methanation and micro reactors are currently under development. Another approach is the biochemical conversion. The bioprocess takes place in aqueous solutions and close to ambient temperatures. Finally, the whole process chain is discussed. Critical aspects of the PtG process are the availability of CO_2 sources, the dynamic behavior of the individual process steps, and especially the economics as well as the efficiency[2].

***Energy management for on-grid and off-grid wind/PV and battery hybrid systems**

Done by kivanc and etal

Renewable energy systems such as photovoltaic (PV) and wind energy systems are widely designed grid connected or autonomous. This is a problem especially in small powerful system due to the restriction on the inverter markets. Inverters which are utilized in these kinds of energy systems operate on grid or off grid. In this study, a novel power management strategy has been developed by designing a wind-PV hybrid system to operate both as an autonomous system and as a grid-connected system. The inverter used in this study has been designed to operate both on-grid and off-grid. Due to the continuous demand for energy, gel batteries are used in the hybrid system. The designed Power Management Unit performs measurement from various points in the system and in accordance with this measurement; it provides an effective energy transfer to batteries, loads and grid. The designed control unit provided the opportunity to work more efficiently up to 10% rate[3].

***Wind Power Plant Prediction by Using Neural Networks**

Done by Z.liu and etal

This paper introduces a method of short term wind power prediction for a wind power plant by training neural networks

Based on historical data of wind speed and wind direction. There are two steps in the process of wind power prediction. In the first step, raw data collected by plant information system is filtered by probabilistic neural network. This step prepares valid data to be used for building a prediction Model. In the second step, a complex-valued recurrent neural network is applied to build a model to predict wind power. The test results of the prediction model are presented and analyzed at the end of the paper. The model proposed is shown to achieve a high accuracy with respect to the measured data[4].

***Preview predictive control layer design based upon known wind turbine blade-pitch controllers**

Done by W.H.Lio and etal.

The use of upstream wind measurements has motivated the development of blade-pitch preview controllers for improving rotor speed tracking and structural load reduction beyond that achievable via conventional feedback control. Such preview controllers, typically based upon model predictive control (MPC) for its constraint handling properties, alter the closed-loop dynamics of the existing blade-pitch feedback control system. This can result in a deterioration of the robustness properties and performance of the existing feedback control system. Furthermore, performance gains from utilising the upcoming real-time measurements cannot be easily distinguished from the feedback control, making it difficult to formulate a clear business case for the use of preview control. Therefore, the aim of this work is to formulate a modular MPC layer on top of a given output-feedback blade-pitch controller, with a view to retaining the closed-loop robustness and frequency-domain performance of the latter. The separate nature of the proposed controller structure enables clear and transparent quantification of the benefits gained by using preview control, beyond that of the underlying feedback controller. This is illustrated by results obtained from high-fidelity closed-loop turbine simulations, showing the proposed control scheme incorporating knowledge of the oncoming wind and constraints achieved significant 43% and 30% reductions in the rotor speed and flap-wise blade moment standard deviations, respectively. Additionally, the chance of constraint violations on the rotor speed decreased remarkably from 2.15% to 0.01%, compared to the nominal controller.[5]

***Geophysical potential for wind energy over the open oceans**

Done by Anna possnera and etal.

Wind turbines continuously remove kinetic energy from the lower troposphere, thereby reducing the wind speed near hub height. The rate of electricity generation in large wind farms containing multiple wind arrays is, therefore, constrained by the rate of kinetic energy replenishment from the atmosphere above. In recent years, a growing body of research argues that the rate of generated power is limited to around 1.5 W m^{-2}within large wind farms. However, in this study, we show that considerably higher power generation rates may be sustainable over some open ocean areas. In particular, the North Atlantic is identified as a region where the downward transport of kinetic energy may sustain extraction rates of 6 W m^{-2} and above over large areas in the annual mean. Furthermore, our results indicate that the surface heat flux from the oceans to the atmosphere may play an important role in creating regions where sustained high rates of downward transport of kinetic energy and thus, high rates of kinetic energy extraction may be geophysical possible. While no commercial-scale deep water wind farms yet exist, our results suggest that such technologies, if they became technically and economically feasible, could potentially provide civilization-scale power[6].

1.5Presentation of the thesis

Chapter one represents the introduction, while chapter two represents the renewable energy; chapter three represents the wind energy and finally chapter four is the conclusion and recommendation of the study.

Chapter Two

Renewable Energy

2.1 Introduction

Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, wind, rain, tides, waves, plant growth and geothermal heat. Renewable energy is derived from natural processes that are replenished constantly, derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources Renewable energy often provides energy in four important areas:

- electricity generation
- air
- water heating ,cooling
- transportation
- rural (off-grid) energy services [7,8]

Renewable energy resources significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Renewable energy comes, ultimately, from the sun. can be use directly (as in solar heating systems) or indirectly (as in hydroelectric power, wind power, and power from biomass fuels).Renewable energy supplies can become exhausted if uses faster than they become replenished. Climate change and global warming concerns, coupled with high oil prices, peak oil, and increasing government support, are driving increasing renewable energy legislation, incentives and commercialization [9,10].

2.2 Types of Renewable Energy Plants

There are many types of Renewable Energy: Solar energy, wind energy, geothermal energy, biomass and bioenergy, hydro power and ocean energy [11].

2.3 Solar Energy

Solar energy is radiant light heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic's, solar thermal energy, solar architecture, molten salt power plants and artificial photo synthesis. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic systems, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light-dispersing properties, and designing spaces that naturally circulate air [12].

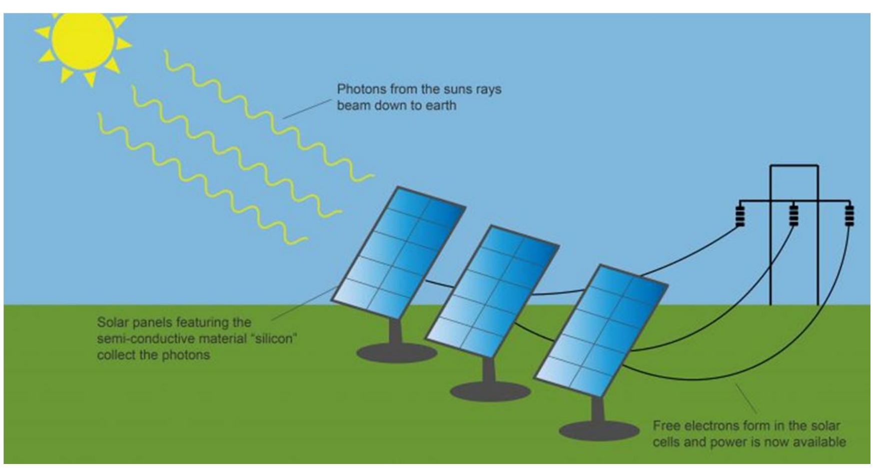

Fig (2.1) solar energy

Solar power (photovoltaic) is one of the of popular, and fastest-growing sources of alternative energy, this process involves solar cells (usually made form slices of crystalline silicon) that rely on the photovoltaic (PV) effect to absorb photons and convert them into electrons. meanwhile, solar-thermal power (another form of solar power) relies on mirrors or lenses to concentrate a large area of sunlight, or solar thermal energy (STE), onto a small area (i.e. a solar cell).Initially, photovoltaic power was only used for small to medium-sized operations, ranging from solar powered devices (like calculators to household arrays [13].The sun will be a source of energy for billions of years. The current technology to capture this energy includes photovoltaic panels, solar collectors and thin-film solar sheeting. The solar cells turn sunlight into electricity directly, so there is no need for a generator. It is a clean, non-polluting source of energy [14].

2.4 Solar Energy Benefits

- After initial capital costs are paid, the energy from the sun is virtually free.
- The sun's energy is unlimited and available everywhere in the world.
- Solar is very flexible and modular. It can provide energy on its own, connected to a grid or jointly with other energy sources.
- Solar can meet a wide range of applications for heat and power and provides an excellent match with summer energy demands.
- Solar systems have few moving parts, are clean to use, use commonly available materials, and provide users with more control over their energy systems[15].

2.5 Solar Energy Challenges

- Solar energy is not always available. Therefore, to be really effective as a continuous source of energy it needs to be stored and integrated with other renewable energy sources.
- All the costs of a solar energy system are required upfront. This means that innovative financing is needed to spread this cost over several years so that capital costs can be paid for out of the income or savings received.
- The cost of a solar energy systems generally does not reflect many of the environmental and peak saving benefits provided by solar.
- The cost of solar systems that generate electricity are coming down rapidly as new manufacturing techniques are introduced, but financial incentives from government will be required for several years to develop a competitive market.
- Some jurisdictions in Canada have not updated their policies to make it affordable for small power producers to connect to the electricity grid.
- Rapid investment in PV cell manufacturing recently outstripped the supply of metallic grade silicon in some countries. This was a temporary problem as silicon is one of the most common elements. New investment and recycling of computer grade silicon by the industry has redressed the problem [15].

2.6 Solar Energy Global Status and Potential

According to the World Watch Institutes' Renewable 2005 report, the fastest growing energy technology is grid-connected solar PV, which grew in existing capacity by 60% per year from 2000—2004. There are more than 400,000 homes in Japan, Germany and the United States that have rooftop solar PV. Global solar PV cell production is expected to climb to over 5 gigawatts per year by 2010 spurred by new initiatives in the United States, Germany, Japan and Spain[15].

2.7 Wind Energy

Wind is a form of solar energy, caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. this wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity. the terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. this mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like. compare to other forms of renewable energy, wind power is considered very reliable and steady, as wind is consistent from year to year and does not diminish during peak hours of demand [16,17].

2.8 Geothermal Energy

Geothermal energy comes from the original Greek word “Geo” which means Earth. Geothermal energy is derived from the heat that is given off by the Earth. For example, steam energy or hot water that is generated by the Earth can be used to generate energy, It is considered to be a renewable source of energy as the water in the Earth is replenished by regular rainfall and the heat used is regularly produced by the planet [18]. Geothermal Energy left over from the original accretion of the planet and augmented by heat from radioactive decay seeps out slowly everywhere, everyday in certain areas, the geothermal gradient)increase in temperature with depth) is high enough to exploit to generate electricity. This possibility is limited to a few locations on

Earth and many technical problems exist that limit its utility. Another form of geothermal energy is Earth energy, a result of heat storage in the Earth's surface. Soil everywhere tends to stay at a relatively constant temperature in the yearly average, and it can be used with heat pumps to heat building in winter and cool a building in summer. This form of energy can lessen the need for other power to maintain comfortable temperatures in buildings, but cannot be used to produce electricity. This thermal energy is contained in the rock and fluids beneath Earth's crust. It can be found from shallow ground to several miles below the surface, and even farther down to the extremely hot molten rock called magma.

Fig (2.2) Geothermal power plant is using their underground reservoirs of steam and hot water to generate electricity and to heat and cool buildings directly.

To produce geothermal-generated electricity, wells, sometimes a mile (1.6 kilometers) deep or more, are drilled into underground reservoirs to tap steam and very hot water that drive turbines linked to electricity generators [19].

2.9 Capturing and Using Geothermal

The most common current way of capturing the geothermal energy is to tap into naturally occurring hydrothermal convection systems containing pressurized hot water or steam. These are forced to the surface and used to drive steam turbine generators, or used to heat hot water or air for space or water heating.

2.10 Geothermal Energy Mechanism

There are three designs for geothermal power plants, all of which pull hot water and steam from the ground, use it, and then return it as warm water to prolong the life of the heat source. In the simplest design, the steam goes directly through the turbine, then into a condenser where the steam is condensed into water. In a second approach, very hot water is depressurized or "flashed" into steam which can then be used to drive the turbine. In the third approach, called a binary system, the hot water is passed through a heat exchanger, where it heats a second liquid—such as isobutene—in a closed loop. The isobutene boils at a lower temperature than water, so it is more easily converted into steam to run the turbine. The three systems are shown in the diagrams below[18,19].

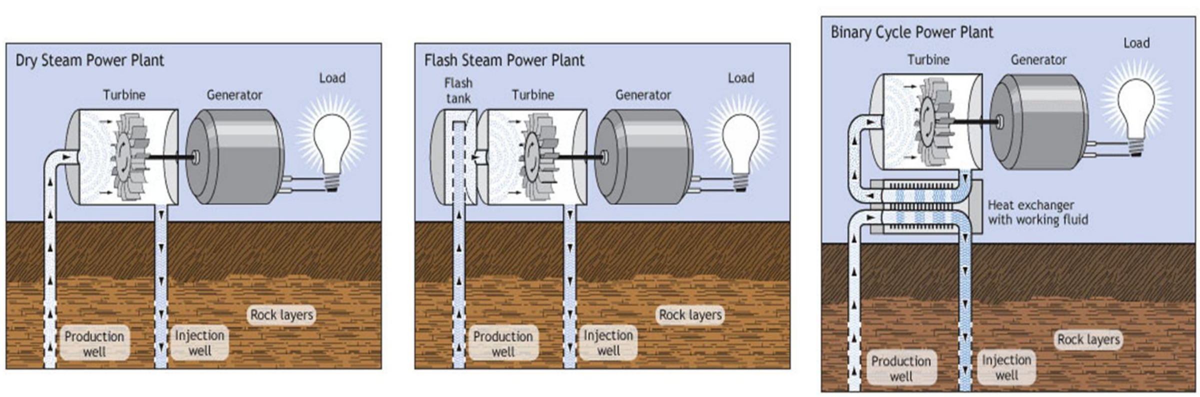

Fig (2-3) Geothermal Energy Mechanism

The choice of which design to use is determined by the resource. If the water comes out of the well as steam, it can be used directly, as in the first design. If it is hot water of a high enough temperature, a flash system can be used; otherwise it must go through a heat exchanger. Since there are more hot water resources than pure steam or high-temperature water sources, there is more growth potential in the heat exchanger design.

2.11 Geothermal Energy Benefits

- Geothermal power plants do not have to use an intermediate technology to produce steam to power the turbine generators.
- The land needed for geothermal power plants is smaller per megawatt than for almost any other type of power plant.
- Geothermal plants can run 24/7 and are flexible; additional units can be installed as necessary.

2.12 Geothermal Energy Challenges

- Geothermal energy can only be used in areas where the earth's crust is thin and the steam or hot water sources are close to the surface.
- Sometimes the hot water that is pumped to the surface contains pollutants such as sulphur, which must be removed before using in a power plant [19].

2.13 Geothermal Energy Global Status and Potential

Geothermal energy is used widely in Iceland, the Philippines, Italy, Indonesia, Mexico, New Zealand, Japan and China. Iceland relies on geysers as its primary source of heat. The United States is the world's largest producer of geothermal electricity with 2,800 MW in service. More than 75 countries have geothermal heating capacity; more than 20 have geothermal electricity capacity. More than 1 GW of geothermal power was added to the global renewable energy equation between 2000 and 2004[19].

2.14 The Advantages and Disadvantages of Geothermal Energy

There are many advantages of geothermal energy. Can be extracted without burning a fossil fuel such as coal, gas, or oil. Geothermal fields produce only about one-sixth of the carbon dioxide that a relatively clean natural-gas-fueled power plant produces. Unlike solar and wind energy, geothermal energy is always available, 365 days a year. It's also relatively inexpensive; savings from direct use can be as much as 80 percent over fossil fuels. The disadvantages of geothermal energy it has some environmental problems. The main concern is the release of hydrogen sulfide, a gas that smells like rotten egg at low concentrations. Another concern is the disposal of some geothermal fluids, which may contain low levels of toxic materials. Although geothermal sites are capable of providing heat for many decades [18, 19].

2.15 Biomass and Bioenergy

Most widely used form of renewable energy is biomass. Biomass simply refers to the use of organic materials and converting them into other forms of energy Bioenergy is a type of renewable energy derived from biomass to create heat and electricity (or to produce liquid fuels used for transportation, like ethanol and biodiesel.

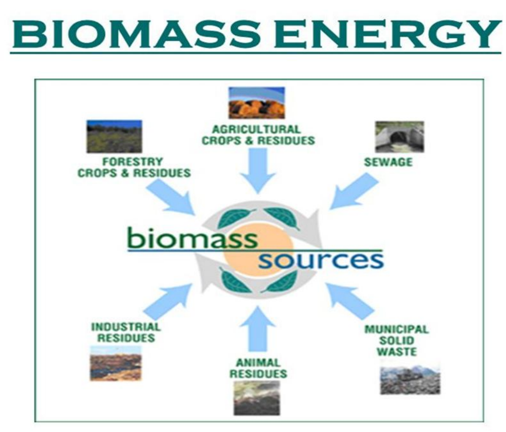

Fig (2.4) Biomass Energy

Unfortunately, most popular is the burning of trees for cooking and warmth,this process releases copious amounts of carbon dioxide gases into the atmosphere and is a major contributor to unhealthy air in many areas. Some of the more modern forms of biomass energy are methane generation and production of alcohol for automobile fuel and fueling electric power plants and use of plant matter and animal waste to create electricity, when converted properly, and it is a low-carbon source of energy with little pollution. Biomass energy is produced from organic matter but the energy that is produced in this fashion is originally provided by the sun. For example, plants absorb the sun's energy through a process called photosynthesis. This energy is then passed on through the organism that eats the plant this creating biomass energy [20].

2.16 The Advantages of Biomass Energy

- Biomass energy is a renewable form of energy
- Biomass energy is a carbon neutral
- Widely available
- cheaper compared to fossil fuels
- Minimizes over dependence of traditional electricity
- Reduces amount of waste in land fills
- Can used to create different product

2.17 The Disadvantages of Biomass Energy

- Biomass energy is not entirely clean
- Risk of deforestation
- Requires a great deal of water
- Inefficient as compared to fossil fuels [21].

2.18 Biomass Energy Benefits

- Bioenergy can provide higher incomes to the agriculture and forestry industries, although this may be tempered by higher costs of land, machinery and other inputs such as fertilizers and pesticides.
- There is a likely reduction in greenhouse gas emissions when compared with conventional fuels over their entire life-cycle. This reduction can turn into increased emissions, however, if the bioenergy use results in a change to the way land is being used. For example, clearing forests to plant an agricultural crop releases a very high amount of greenhouse gas emissions that negate any climate benefit from the new crop itself.
- Some bioenergy sources can improve air quality by either improving the way the biomass was previously disposed, or by burning cleaner than conventional fuels. For example, burning wood waste in a power plant with high quality pollution prevention technologies is much cleaner than older methods of disposing of the waste such as beehive burners. Biodiesel is also known to result in much lower air pollution than conventional diesel [21].

2.19 Biomass Energy Challenges

- Bioenergy that comes from dedicated crops have several potential risks. These include possible impact on food prices and availability, and land and water impacts of conventional agriculture. Bioenergy from dedicated land may also directly or indirectly result in land being cleared for new crop growth - a practice that can lead to deforestation, erosion and a very high release of greenhouse gas emissions.
- Collecting and processing biomass resources in sufficient quantities can be a challenge. The energy needed to grow, cut and transport crops to a bioenergy plant and then process these materials into fuels or power is not insignificant. Waste or residue biomass resources have the lowest

energy requirements, while agricultural crops usually have the highest[21].

2.20 Biomass Energy Global Status and Potential

In 2003, the European Union has adopted two biofuel directives. These directives set targets for the share of renewable fuels in the transport fuel market (2% by the end of 2005 and 5.75% by the end of 2010). The 2005 target was not achieved but the industry is growing rapidly and it expected that the 2010 target will be achieved. The EU has also adopted a Biomass Action Plan that sets out measures to increase the development of biomass energy from wood, wastes and agricultural crops by creating market-based incentives for its use and removing barriers to the development of the market. Implementation of the plan will help the EU to cut its dependence on fossil fuels, reduce greenhouse gas emissions and stimulate economic activity in rural areas. Brazil is the world's largest producer of Biofuels. Production is expected to rise from 15.4 billion liters in 2004 to 26.0 billion liters by 2010. Ethanol from sugarcane provides 50% of automobile fuel in Brazil[21].

2.21 Hydropower Energy

Hydropower or waterpower (from Greek: ύδωρ, "water") is power derived from the energy of falling water or fast running water. This may be harnessed for useful purposes. Since ancient times, hydropower from many kinds of watermills has been used as a renewable energy source for irrigation and the operation of various mechanical devices, such as gristmills, sawmills, textile mills, trip hammers, dock cranes, domestic lifts, and ore mills. A tromped, which produces compressed air from falling water, is sometimes used to power other machinery at a distance [22].

Fig (2.5) hydropower energy

Hydroelectric energy is from uses the gravitational potential of elevated water that was lifted form oceans by sunlight. It is not strictly speaking excavation to become useful again. At this time, most of the available locations for hydroelectric dams are already used in the developed world [23].

2.22 Advantages of Hydropower Energy

1. Once a dam is constructed, electricity can be produced at a constant rate.

2. If electricity is not needed, the sluice gates can be shut, stopping electricity generation. The water can be saved for use another time when electricity demand is high.

3. Dams are designed to last many decades and so can contribute to the generation of electricity for many years.

4. The lake that forms behind the dam can be used for water sports and leisure, Often large dams become tourist attractions in their own right.

5. The lake's water can be used for irrigation purposes.

6. The buildup of water in the lake means that energy can be stored until needed, when the water is released to produce electricity.

7. When in use electricity produced by dam, systems do not produce greenhouse gases and they do not pollute the atmosphere.

2.23 Disadvantages of Hydropower Energy

1. Dams are extremely expensive to build and must be built to a very high standard.

2. The high cost of dam construction means that they must operate for many decades to become profitable.

3. The flooding of large areas of land means that the natural environment is destroyed.

4. The building of large dams can cause serious geological damage.

5. Although modern planning and design of dams is good, in the past old dams have been known to be breached (the dam gives under the weight of water in the lake). This has led to deaths and flooding.

6. Dams built blocking the progress of a river in one country usually means that the water supply from the same river in the following country is out of their control. This can lead to serious problems between neighboring countries.

7. Building a large dam alters the natural water table level [24].

2.24 Hydropower Energy Benefits

- Hydropower is a complementary power source to more intermittent renewable energy power sources such as wind and solar because the flow can be regulated to reserve generating capacity during periods of peak demand or when the generating capacity of other renewable energy sources is limited.
- Small hydro facilities can be integrated into existing irrigation structures, flood control and dams. Because existing structures are used, adding generating capacity only requires the construction of small engineering works.

- Small hydro production has an important role to play in providing electricity to remote communities and industries in developing countries where rural electrification via the grid is not practical.
- In Canada, hydroelectric generation can provide clean electricity and a source of income to many remote communities that would otherwise be forced to rely on diesel generation.
- Hydroelectric energy is a proven technology, and hydroelectric stations have a long life[24].

2.25 Hydropower Energy Challenges

- Larger hydro plants, especially those that involve the construction of dams, can have serious impacts on local communities and the upstream and downstream environment. There are many examples of hydro plants around the world where whole communities have been moved, lost their livelihood or had their health compromised.
- Large hydro plants can play an important role in providing electricity if guidelines and best practices are applied in their design, construction and operations; local communities are involved in planning processes; and environmental and social impacts are minimized.
- Hydroelectric reservoirs present a number of challenges, including: reservoirs produce greenhouse gas emissions because of decaying vegetation from flooded lands, particularly in tropical regions reservoirs typically result in higher levels of naturally occurring mercury in water resources, which is released from land that is flooded silt deposits can shorten the operational lifespan of hydroelectric reservoirs.
- Small run-of-river hydro plants are not exempt from challenges including frazil ice (slush formed in water that is too turbulent to freeze over) and pipeline freezing must be considered seasonal flows affect revenues fish migration can be a concern in which case conservation

measures (e.g., fish guidance, habitat compensation) have to be implemented[24].

2.26 Hydropower Energy Global Status and Potential

China has developed more than half of the world's small hydro capacity. In 2004 alone, the country added nearly 4 GW of small hydropower. Other countries actively pursuing small hydropower include Canada, Australia, Nepal and New Zealand. Small hydropower is often used to supply electricity in remote or autonomous locations, such as rural villages that are not connected to the electrical grid. Hydropower may replace existing diesel generators or provide a community with electricity for the first time. A recently completed inventory of Canadian small hydro sites identified over 5,500 sites with a technically feasible potential of about 11,000 MW, but only about 15 per cent of these are economically feasible to develop. Over the last decade, the small-scale hydroelectric industry has contributed about $100 million per year to the Canadian economy in manufacturing and services and added about 30 to 50 MW yearly to Canada's power supply[24].

2.27 Ocean Energy

Ocean energy is one of renewable energy sources. Oceans cover more than 70% of Earth’s surface and they therefore present interesting energy source that may with time provide us with energy to power our households and industrial facilities. At this moment ocean energy is renewable energy source very rarely used, as there are a few ocean energy, and most of these power plants are very small so energy gained form oceans is negligible on global scale. There should be significant increase in produced energy, especially with more attention to renewable energy sector [25].There are three basic types that allow us to use ocean for its energy. We can use the waves (wave energy, wave power), ocean tidal power (ocean high and low tides), and we can even use temperature differences in the water to create an energy (Ocean Thermal Energy Conversion,) [26].

Fig (2.6) Harnessing the Ocean Energy

The oceans on Earth can be used in many ways to generate electricity, and are being studied due to their potential to create renewable energy. Two of the main technologies are to harness tides and waves to generate electricity.

2.28Advantages of Ocean Energy

- Once the capital investment is made, the electricity is cheaper than other sources because the source of the energy is free.
- There are less carbon dioxide emissions because no fossil fuel is burned to generate the electricity.
- Power can be generated in the United States, resulting in fewer imports from politically unstable regions.

2.29 Disadvantages of ocean energy

- The capital investment on a wave or tidal system takes a long time to earn back, depending on the size of the system and method used.
- Some ecosystems, especially in estuarine environments, may suffer because tidal flats retain more water than is natural when they are dammed.

- No current infrastructure to move electricity generated far out at sea back inland, so current usage is near to the shore where equipment can be an eyesore [27].

2.30 Wave Power

To generate wave power, there are two different methods used to harness the energy in the water. Firstly, the oscillations of the water are used to drive pumps, and therefore the power depends on the kinetic energy of the waves. For the second method, barriers and ramps are designed to increase the height of the wave above sea level, and the falling of the water results in the conversion of gravitational potential energy to electricity.

2.31 Tidal Power

To generate tidal power, the range between the high and low tides in a specific area are used to create power. For most tidal energy, this requires a large dam like wall across an estuary with turbines capable of turning the gravitational potential energy caused by the tidal difference into electricity.

2.32 Some Of the Challenges with This Renewable Resource Include

- This technology has not advanced as quickly as wind and solar, so it remains expensive.
- If not managed correctly, it can have a negative impact on the environment [27].

Chapter Three

Wind Energy

3.1 Introduction

The original source of the renewable energy contained in the earth's wind resource is the sun. Global winds are caused by pressure differences across the earth's surface due to the uneven heating of the earth by solar radiation. For example, the amount of solar radiation absorbed at the earth's surface is greater at the equator than at the poles. The variation in incoming energy sets up convective cells in the lower layers of the atmosphere (the troposphere). In a simple flow model, air rises at the equator and sinks at the poles the circulation of the atmosphere that results from uneven heating is greatly influenced by the effects of the rotation of the earth (at a speed of about1670 kilometers per hour at the equator, decreasing to zero at the poles). In addition, seasonal variations in the distribution of solar energy give rise to variations in the circulation. The spatial variations in heat transfer to the earth's atmosphere create variations in the atmospheric pressure field that cause air to move from high to low pressure here is a pressure gradient force in the vertical direction, but this is usually cancelled by the downward gravitational force. Thus, the winds blow predominately in the horizontal plane, responding to horizontal pressure gradients at the same time, there are forces that strive to mix the different temperature and pressure air masses distributed across the earth's surface.

In addition to the pressure gradient and gravitational forces, inertia of the air, the earth's rotation, and friction with the earth's surface (resulting in turbulence), these affect prevailing near surface winds. That this model is an oversimplification because it does not reflect the effect that land masseshave on the wind distribution [28].

Fig (3.1) wind energy

3.2Wind Energy Development

Wind power is widely used in Europe, China, and the United States. From 2004 to 2014, worldwide installed capacity of wind power has been growing from 47 GW to 369 GW—a more than sevenfold increase within 10 years with 2014 breaking a new record in global installations (51 GW). As of the end of 2014, China, the United States and Germany combined accounted for half of total global capacity. Several other countries have achieved relatively high levels of wind power penetration, such as 21% of stationary electricity production in Denmark, 18% in Portugal, 16% in Spain, and 14% in Ireland in 2010 and have since continued to expand their installed capacity More than 80 countries around the world are using wind power on a commercial basis.

3.3 Offshore Wind Power

As of 2014, offshore wind power amounted to 8,771 megawatt of global installed capacity. Although offshore capacity doubled within three years (from 4,117 MW in 2011), it accounted for only 2.3% of the total wind power capacity. The United Kingdom is the undisputed leader of offshore power with half of the world's installed capacity ahead of Denmark, Germany, Belgium and China [29].

3.4 The Uses of Wind Energy

One of the most popular uses of wind energy today is for wind power generation. During this process, a wind turbine is used to harness the energy of the wind. The wind starts to move the turbine blade and generator starts to turn which produces electricity. Wind power has greatly increased in its popularity and efficiency since the first electricity generating turbine was created by Scottish academic James Blyth back in 1887 to provide electricity for the lighting. Today, the technology exists to allow us to build vast wind farms that have a capacity in excess of 1,000 MW[30].

3.5 Transportation

Another use of wind energy is in transportation. Civilizations have for many thousands of years used wind energy in transportation in the form of sailing. Researchers believe that sailing has been in existence in some form since as far back as 5000 BC. In more recent times, we have seen both small and large ships capable of sailing under the power of the wind. Some modern shipping companies are beginning to embrace wind energy as a use in transportation. Vessel’s including fishing trawlers and even cargo ships have had large kites installed that are capable of helping to reduce fuel consumption on long journey’s by as much as 30% under the right conditions[30].

3.6 Wind Sports and Activities

A more enjoyable use of wind energy is for sports and activities that rely on the power of the wind[31].

Some of the sports that make use of the winds energy

- Windsurfing

- Sailing – This more traditional use of wind energy
- Land Sailing.
- Kite Surfing
- Kite Boarding
- Kite Buggying

These sports are classed as “air sports”.

3.7 Food Production

Wind energy has traditionally been used for food production purposes through the use of windmills. Prior to the industrial revolution, these structures were widely used for milling grain so that it could be then used for producing food such as bread. In more recent times, the introduction of electricity and motors has eliminated our need for such structures and factories can now produce items such as flour much more efficiently [32].

3.8 Pumping Water

Wind energy can also be used for pumping water through the use of a wind pump. Wind pumps have a similar look to a traditional windmill but instead of milling grain, they can pump water. These structures were historically used for draining land. Similarly to the windmills used in food production, these structures have almost all been replaced due to the introduction of electrical motors. We can use wind energy for enjoyment, or to reduce carbon footprint or to even reduce our dependency on fossil fuels [32].

3.9 Advantages of Wind Energy

1. The wind is free and with modern technology, it can be captured efficiently.
2. Once the wind turbine is built the energy it produces does not cause green house gases or other pollutants.

3. Although wind turbines can be very tall each takes up only a small plot of land. This means that the land below can still be used. This is especially the case in agricultural areas as farming can still continue.

4. Many people find wind farms an interesting feature of the landscape.

5. Remote areas that are not connected to the electricity power grid can use wind turbines to produce their own supply.

6. Wind turbines have a role to play in both the developed and third world.

7. Wind turbines are available in a range of sizes which means a vast range of people and businesses can use them. Single households to small towns and villages can make good use of range of wind turbines available today [32].

3.10 Disadvantages of Wind Energy

1. The strength of the wind is not constant and it varies from zero to storm force. This means that wind turbines do not produce the same amount of electricity all the time. There will be times when they produce no electricity at all.

2. Many people feel that the countryside should be left untouched, without these large structures being built. The landscape should left in its natural form for everyone to enjoy.

3. Wind turbines are noisy. Each one can generate the same level of noise as a family car travelling at 70 m/h.

4. Many people see large wind turbines as unsightly structures and not pleasant or interesting to look at. They disfigure the countryside and are generally ugly.

5. When wind turbines are being manufactured some pollution is produced. Therefore, wind power does produce some pollution.

6. Large wind farms are needed to provide entire communities with enough electricity.

7. Threatening wild life [33].

3.11 Wind Turbines

Is a device that converts the wind's kinetic energy into electrical energy.Wind turbines are manufactured in a wide range of vertical and horizontal axis types. The smallest turbines are used for applications such as battery charging for auxiliary power for boats or caravans or to power traffic warning signs. Slightly larger turbines can be used for making contributions to a domestic power supply while selling unused power back to the utility supplier via the electrical grid. Arrays of large turbines, known as wind farms, are becoming an increasingly important source of intermittent renewable energy and are used by many countries as part of a strategy to reduce their reliance on fossil fuels. Wind was shown to have the "lowest relative greenhouse gas emissions, the least water consumption demands and the most favorable social impacts" compared to photovoltaic, hydro, geothermal, coal and gas[27].Most wind turbines in use today are horizontal axis units, or HAWTs, with three blades attached to a central hub Together the blades and the hub form the rotor In many wind turbines the rotor is connected to a shaft that runs horizontal to the ground, hence the name It is connected to an electrical generator. When the winds blow the rotor turns and the generator produces alternating current (AC) electricity. One of the key components of a successful wind generator is the blades; they capture the wind’s kinetic energy and convert it into mechanical energy (rotation). It is then converted into electrical energy by the generator the generators of wind turbines are often protected from the elements by a durable housing made from fiberglass or aluminum. However, in many modern small wind turbines, the generators are exposed to the elements.Most wind turbines in use today have tails that keep them pointed into the wind to ensure maximum production [34].

3.12 Wind Turbine Design

At the heart of any renewable wind power, generation system is the Wind Turbine. Wind turbine designs generally comprise of a rotor, a direct current (DC) generator or an alternating current (AC) alternator which is mounted on a tower high above the ground. A wind turbine is the opposite to a house or desktop fan. The fan uses electricity from the mains grid to rotate and circulate the air,. Wind turbine designs on the other hand use the force of the wind to generate electricity. The winds movement spins or rotates the turbines blades, which captures the kinetic energy of the wind and convert this energy into a rotary motion via a shaft to drive a generator and make electricity as shown [35].

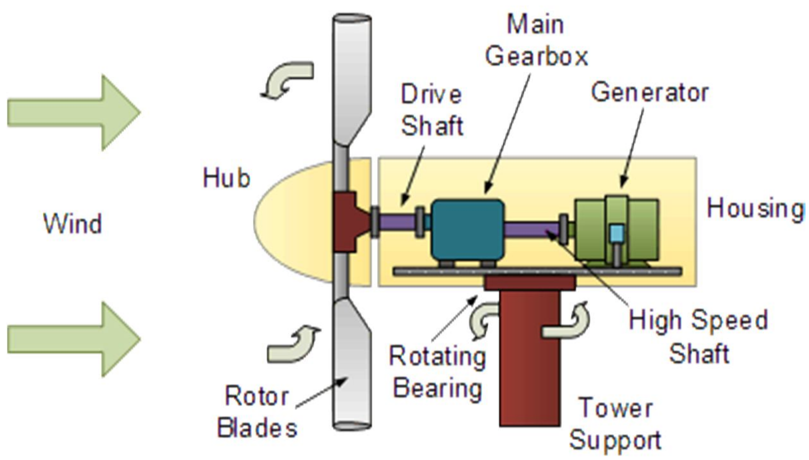

Fig (3.2) Typical Wind Turbine Generator Design

3.13 Types of Wind Turbine

There are two types of wind turbine

3.13.1 Horizontal Axis Wind Turbine

It can be further divided into three types:

- Dutch type grain grinding wind mills
- Multi-blade water pumping windmills
- High speed propeller type windmills

3.13.2 Vertical Axis Wind Turbines

It comes in two different designs

- The savories rotor
- The durries rotor

The most turbine blade has single blade, double blade or three blades [36].

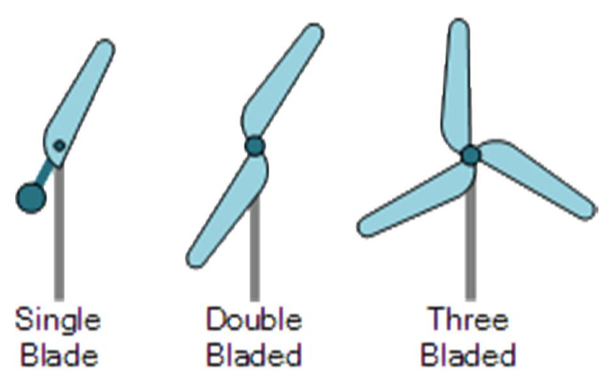

Fig (3.3) turbine blade

3.14 Wind Mill

A windmill is a machine that converts the energy of the Wind into other, more useful forms like mechanical energy.

Fig (3.4) windmill

Early windmills were designed to grind grain and pump water. Later on, windmills were designed to generate electricity. Electricity-generating windmills are commonly referred to as wind turbines or wind generators. Water pumping windmills are generally referred to as such or simply as windmills [37].

3.15 The Mechanism of the Wind Energy

Converting wind energy to kinetic energy. To convert energy form wind to kinetic, wind blades of a wind turbine is used. There are various types of wind blades with different coefficient performance for each. When the wind passes through the wind blades, the blades will rotate. The wind itself contains a high amount of kinetic energy caused by the movement of the wind. Once it passes through the wind blades, the kinetic energy in the wind is reduced significantly. The turbine will rotate and the rotation of the blades will generate its own kinetic energy [38].

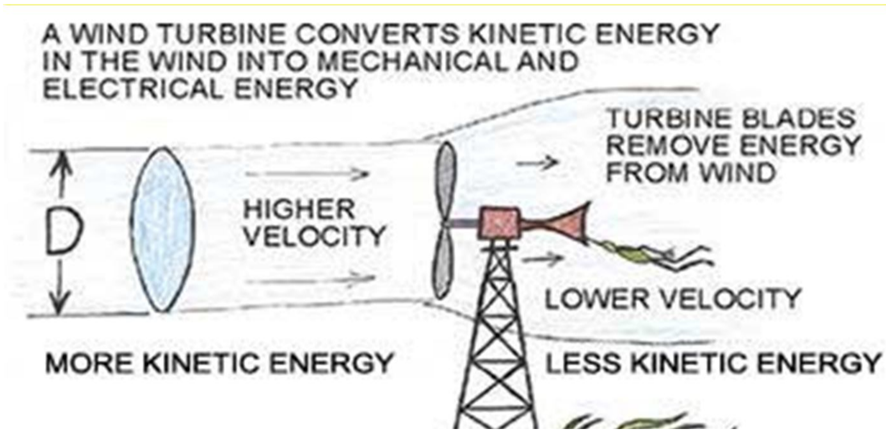

Fig (3.5) Kinetic Energy Transfer From Wind To Blades

The amount of available energy in the wind can be derived using the kinetic energy equation:

$$E = \frac{1}{2} m v^2 \qquad (3.1)$$

E = energy of the wind

$m = mass$ of air

v =velocity of the wind

The mass of air is derived from the flow rate equation for air:

$$m = pvAt \qquad (3.2)$$

$m = mass$ of air

v =velocity of the wind

A =area of wind

t =time

p =power of wind

The available energy in wind

$$E = \frac{1}{2} p v^3 t \qquad (3.3)$$

It is theoretically impossible for a wind turbine to extract 100%. This is because in order for the turbine to actually rotate, there must be a difference in velocity on both sides. The wind velocity will need to be significantly lower after passing through the turbine [39].If there is no wind velocity difference, the turbine will simply not move. This is the basic physics explanation for the wind turbine maximum efficiency. The turbine's blade design is similar to that of an aero plane 'swing. Due to its shape, the curve side will have higher velocity compared to the flat area. Based on Bernoulli's theorem, as the velocity is higher, the pressure is lower. This would mean that the higher pressure will push the blades to rotate, creating a lift force[39].

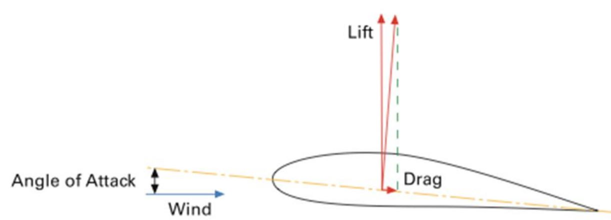

Fig (3.6) The Lift And Drag Force Acting On A Turbine Blade

The lift force increases as the turbine is turned to higher angle of attack. However when the angle of attack becomes too large, it increases the drag force of the wind. This can cause the wind turbine to stall. A good ratio of lift force over drag force is required for a good turbine[40].

3.16 Converting Kinetic Energy to Mechanical Energy

The kinetic energy from the movement of the turbine blades will then be converted to mechanical energy within the turbine

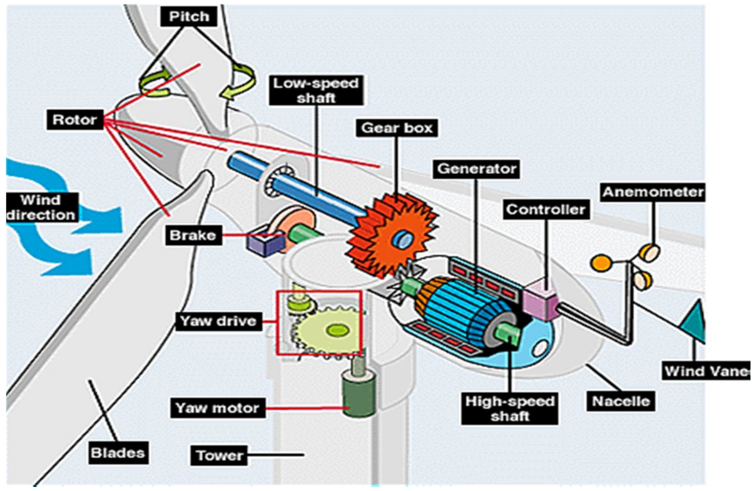

Fig (3.7) Mechanical Component In A Wind Turbine

The blades of the wind turbine will be connected to the low-speed shaft. The rotation of the blades will cause the shaft to rotate as well and this produces torque [41].Based on the equation of

$$\tau = f * r \quad (3.4)$$

τ =torque

f =force

r =distance (radius of shaft)

The large radius will produce large torque but low angular velocity, in order to increase the velocity, a gearbox is used. The gearbox is then connected to a high-speed shaft within a generator. In some wind turbine, a low speed generator is used. This would mean that the low speed shaft can be connected directly to the generator without using gearbox. The final requirement in the mechanical energy is that velocity must be produced by rotation of the shaft.

3.17 Converting Mechanical Energy to Electrical Energy

The rotation of the shaft is then converted in to electrical energy by using a generator. When mechanical energy is exerted and supplied to rotate the coil inside the generator at uniform angular velocity, a magnetic field is created due to the permanent magnet inside the generator. This creates a sinusoidal electromotive force, which is similar to a voltage.based on faraday's law [42].

$$E = Bv \qquad (3.5)$$

E = electromotive force

B = flux density of a constant magnetic field

V = velocity

When a resistance is applied, current is produced.

Ohms law indicates that the potential difference across any conductor the current passes through it is directly potential to this p.d

$$V = IR \qquad (3.6)$$

V = velocity

I = current

R = resistance

Since electromotive force acts as a voltage, replacing the equation yield the new equation

$$Bv = IR \qquad (3.7)$$

$$I = \frac{Bv}{R} \qquad (3.8)$$

This shows how current and voltage are produced from the various energy conversions that take place in order to harness energy from the wind to produce electricity [43].

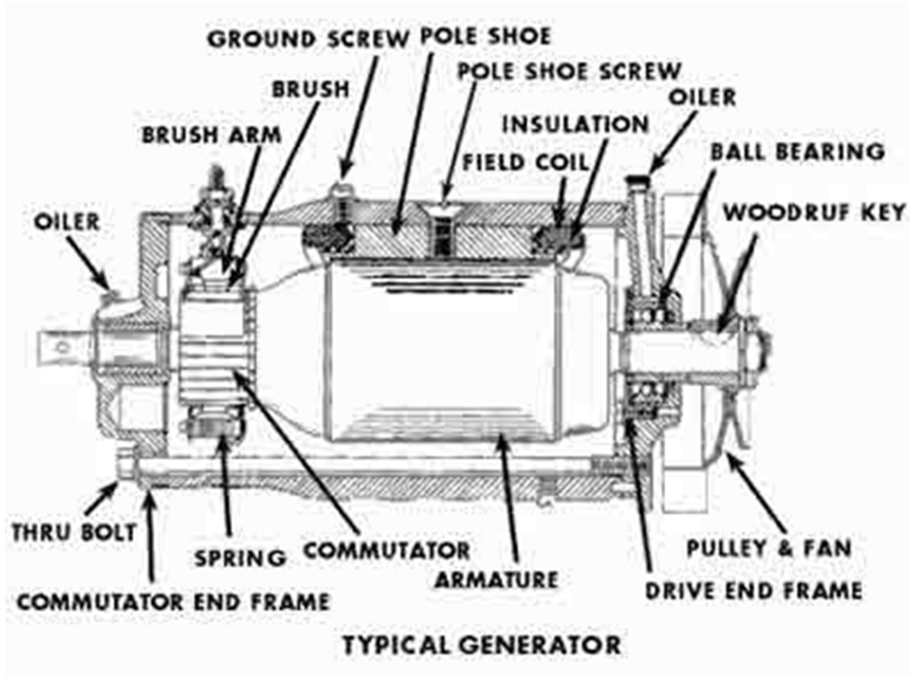

Fig (3.8) Atypical Generator Design

3.18 Factors Affecting Wind Energy Production

The most important factor when it comes to efficiency of a wind energy system is the availability of wind. This can be associated with the geographical location of the wind farm [44].

3.19 Rated Wind Speed

It is common misconception that the faster the wind is, the more power the turbine can produce. However, each specific turbine has rated power output based on the turbine's design [45].

3.20 Wind Sweep Area

Based on the theoretical power equation;

$$Pt = \frac{1}{2}\rho A v^3 \qquad (3.9)$$

Pt = theoretical power

V = velocity

A =wind sweep area

The wind sweep area, A, influences the amount of power that a wind turbine may harness. The wind sweep area for the wind turbine is the area of the circle that the turbine blades rotate

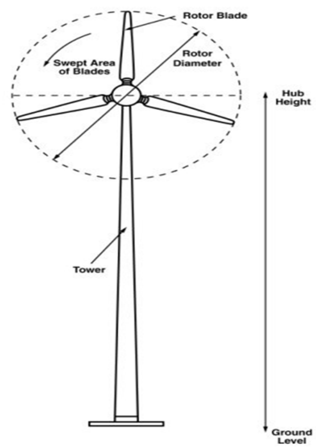

Fig (3.9) Wind Sweep Area

The larger the area, the more power it can generate. However, a large turbine would also be very heavy, and would require a strong tower structure and will also create a large unwanted drag force due to its large mass. The appropriate size of the wind turbine considering all the variable such as weight, cost and efficiency need to be factored in before decided on the size of the wind sweep area [46].

3.21 Types of Turbines

Different types of turbines have different coefficient of performance. Wind turbines have much lower efficiency than that and it is heavily dependent on the type of the turbine and the design of the turbine itself. The higher the coefficient of performance, better the potential to generate higher electricity [47].

3.22 Lift and Drag Ratio

When wind passes through a turbine's blade, it causes the turbine blade to experience both lift force and drag force. By optimizing the lift /drag force ratio, the optimum angle of attack can obtained [48]

Fig (3.10) various angle of attack

A low angle of attack will have low drag force, but also low lift force .in order to increase the lift force, a higher angle of attack is introduced. If the angle of attack goes too high, the drag force increases and the lift force reduces drastically. Therefore, it is very important to optimize the angle of attack to get the maximum lift force.

3.23 Optimal Tip Speed Ratio

Tip speed ratio is defined as the ratio of the speed of the rotor tip to the free stream wind. This is very important in determining the efficiency of a wind energy system. If the TSR is too low, it show the rotor is spinning too slowly. This would allow much wind to pass through undisturbed; hence the turbine does not extract as much energy as it is capable of. However, if the turbine rotates too quickly and a high value of TSR exists, this would just create a large drag force and prevent air from passing through [49]. The TSR value is determine by

- Turbine blade design
- Number of blades
- Type of wind turbine.

3.24 Mechanical Efficiency

There would be an energy lost when the conversion from kinetic energy to mechanical energy takes place. This is mostly due to the bearing and the generator that is used [50].

3.25 Challenges

Despite the economic and ecological advantages, so far even good wind resources in developing and emerging countries have not been used to the desirable extent. The essential reasons for this are based in the lack of knowledge in the developing and emerging countries. From the view of international wind energy companies, beside the difficulties of raising of capital and risk covering, the barriers for private investment are especially [51].

- Lack of information on foreign markets
- Lack of knowledge of the energy-sector framework conditions and support mechanisms
- Insufficient wind energy legal framework (technical and economical conditions for feeding wind-generated electricity into power grids, permit procedure, ...)
- Lack of qualified staff, especially in the field of service/maintenance [8]. Technicians and buyers are often unfamiliar with wind technology, and in remote locations installments often break down because of a lack of servicing, spare parts, or trained manpower to administer them. In reality, wind pumps are less maintenance intensive than diesel pumps. However, the wind pump technology is "strange" to many people and there is a need to train maintenance staff where pumps are installed.

- Infrastructure to support the installation, commissioning and maintenance of wind generators is not developed. Users and technicians are generally unaccustomed to the technology.
- Investment Cost. Although the lifetime cost of wind is often less than diesel or petrol-powered pumps, the investment cost of purchasing a wind pump is usually higher than that of diesel pumps. Groups purchasing water supplies often have limited funds and cannot take a long-term view toward the technology.
- Wind energy does not have as consistent an output as fuel-fired power plants. Small-scale wind generators require battery storage to allow usage in periods of low or no wind. For grid connected systems, a stable grid is required to act as the storage. Wind pumps require water storage.
- Wind generators are designed to work over a given range of wind speeds, usually 4– 12m/s. This means that the technology can only be used in areas with sufficient winds .

Chapter Four
Conclusion and Recommendations

4.1 Conclusion

*The wind energy is available.

*Wind energy is also a renewable source.

*We do not need to wait for formation wind energy.

*The wind energy does not contribute to the exhaust of deadly pollutant.

*Use of an indigenous resource without producing greenhouse gases or other pollution.

*Wind energy contributes to the power supply diversification,

*Wind energy projects can develop local resources in terms of labor, capital and materials.

*Wind projects reinforce the cooperation with different donors including Germany, enhancing local capacities and technological know-how.

*Wind projects attract new capital and can be included in the new approach of Independent Power Production (IPP).

4.2 Recommendations

*Wind energy can be used to create different products.

*Wind energy used to make electricity with wind turbine.

*Wind energy used to make mechanical power, with windmill and for pumping water or drainage with wind pump.

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