Renewable Hybrid Power Harvesting for Domestic and Commercial Application

Final Year Design Project

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Final Year Project submitted to the Department of Electrical Engineering, Grafton College, and Islamabad in partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering in Electrical Engineering.

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بسم الله الرحمن الرحيم

In the name of Allah (SWT), the most beneficent and the most merciful.

Certificate of Approval

This is to certify that the work contained in this report entitled

''Renewable Hybrid Power Harvesting for Domestic and Commercial Application''

was carried out by

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under my supervision and that in my opinion, it is fully adequate, in scope and quality, for the degree of BSc. Electrical Engineering from

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Dedications

To my parents, siblings and extended family, who have provided me with unweaving love and support throughout the duration of this project.

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We express our gratitude to Allah for granting us the resilience and determination that have propelled us this far in our journey and enabled us to achieve our objectives for our final year project. The process of completing this project has been a valuable learning experience, and we are appreciative of the challenges we encountered along the way. These difficulties have allowed us to discover our true potential and capabilities. We extend our sincere thanks to our supervisor, Dr. Hidayatullah Khan, for his unwavering support and guidance throughout this project. Additionally, we would like to acknowledge the teachers who consistently encouraged us to persevere in the face offailures. Without the assistance of our mentors, this project would not have been possible. We are also grateful to Grafton College for affording us the opportunity to pursue this engineering program and for providing us with the necessary resources during our four years of education. May Allah grant us the strength to accomplish even more.

Abstract

Vertical Axis Wind Turbines (VAWT) represents a unique form of energy production technology. Historically, they have been relegated to filling a small niche market in commercially available wind turbines due to their "no-tilt" design. Current VAWT designs lag behind their horizontal wind turbine (HAWT) counterparts in terms of efficiency, as measured by their coefficient of performance. However, new research suggests that these types of wind turbines may be more suitable for wind farm installations than previously thought. In this chapter, on-farm VAWT research will be reviewed and discussed. This will be followed by an overview of the various parameters for VAWT design, focusing on designs suitable for installation in an optimized wind farm.

Key words: HAWT, VAWT, No-Tilt, Optimized wind farm.

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Chapter 1:

Introduction:

With the rapid growth of the industrial economy and world population, conventional energy sources such as fossil fuels are no longer sufficient to meet energy demands. The utilization of renewable/sustainable energy sources, in the form of light, heat, wind, wave, vibration, rotation, etc., becomes an effective and promising solution to deal with the global energy crisis . Over the past decade, a large number of researches and efforts have been involved to environmental energy harvesting techniques. Such energy sources are utilized to generate macro scale (>W level) electricity for industrial and household use, and hence alleviate the shortage of local power supply. In the meantime, energy harvesting research focusing on micro scale power (harvesting research focusing on micro scale power (has attracted more and more attention worldwide for the replacement of millions of batteries in portable/wearable electronics and wireless sensor nodes (WSNs), thus realizing self-charging electronics and self-powering smart WSN systems [6–9]. Such energy harvesters scavenge ambient renewable/sustainable energy sources and convert them into electricity by implementing various transduction mechanisms such as photovoltaic, thermoelectric, pyro electric, piezoelectric, electromagnetic, turboelectric, and so on, providing sustainable power solutions.

Vertical wind turbines (VAWT) are a type of wind turbine that rotate around an axis perpendicular to the incoming flow. The two main advantages of this family of wind turbines are related to the collection of wind from any direction and the possibility of installing the power generation system close to the ground surface, which reduces operation and maintenance costs . As the area of VAWTs can be increased regardless of their footprint, they also have the potential to provide higher power densities compared to traditional horizontal axis wind turbines (HAWTs). In addition to the above advantages associated with VAWT, recent studies show that there is potential for increasing the performance of existing wind farms (or optimizing the layout of new wind farms) by deploying wind turbines of different types and combinations of horizontal and vertical-axis wind turbines.

1.1. History of Vertical Axis Wind Turbines:

European style grain grinding windmills, like the ones attacked by Don Quixote, is what usually comes to mind when thinking of early-age wind power. However, even if these types of horizontal axis windmills were introduced in Europe no later than the 12th century, the first recordings of wind turbines are from the 9th century describing Persian vertical axis windmills. Actually, vertical axis windmills might have been in use in the Afghan highlands as early as the 7th century BC. These early VAWTs where simple devices based on aerodynamic drag, the wind was simply pushing the blades of the turbine and thus creating torque. Using aerodynamic lift created by pressure difference due to the shape of the blade is far more efficient than using drag and the first lift-based vertical axis wind turbines were invented by Darrieus in 1931. Darrieus patent cover both the troposkein “egg beater” shaped turbine with curved blades mounted directly to the rotating tower/shaft that is supported by guy wires at the top and the so called H-rotor with straight blades and struts connecting them to the shaft placed inside the tower. 14 During the 1970-80s there where large research programs in North America focusing on the Darrieus concept, for example Sandia National Laboratories1 tested different configurations and sizes of the Darrieus turbine. A company called The FloWind Corp utilized much of the Sandia technology to build commercial wind farms using turbines ranging up to 300 kW which initially proved to be quite reliable and efficient. In Quebec, a record-breaking 4.2 MW Darrieus turbine known as Éole C was built in the late 1980s. However, during this period the blades which were designed to flex, were usually made of aluminum which is not very endurable to cyclic stress, so with time problems with fatigue on the blades started to appear which ultimately lead to failures. These problems together with withdrawal of funding finally stalled the development. Today most of the VAWT projects regard small scale turbines like Ropatec from Italy, Turby from the Netherlands or the innovative Swedish offshore concept SeaTwirl which features a floating tower and kinetic energy storage using sea water. In recent years there has been a renewed interest in larger VAWTs, not least because of findings within the VAWT research project at the Division for Electricity at Uppsala University which the author of this thesis takes part in.

1.2. The 200kW VAWT “T1-turbine:

A 200 kW VAWT, a so called H-rotor which is a Darrieus- type turbine with straight blades, was designed and erected by the company Vertical Wind AB2 in 2010. The turbine is hereafter referred to as the T1-turbine. The turbine is located just outside of Falkenberg at the west coast of Sweden. It is today owned by Uppsala University and serves as a subject of research in a variety of fields. It has a direct drive synchronous generator with a 36-pole rotor that is permanent magnetized with neodymium-iron-boron magnets. The generator is designed to have high overload capacity so that all possible operational conditions can be handled. The generator is connected to a full frequency converter, situated in a nearby substation, which allows variable speed. Furthermore, the generator is mounted at the bottom of the tower and connected to the rotor by a steel shaft. The shaft is jointed in the middle and supported by two bearings in the top of the tower as well as the bearings of the generator. Since all the moving parts are connected and rotating with the same speed, this configuration can be said to have only one moving part in the entire turbine. The generator has the ability to brake electrically, serving as primary brake system. A hydraulic disc brake placed at the top of the tower works as secondary brake and is used for emergency braking and parking during maintenance. The rotor consist of three 24 m long straight blades that are connected to the shaft by two struts each, both blades and struts are made out of fiberglass. The blades are fixed, but the variable speed of the turbine is used to control the stall effect so that the rated power can be attained between the rated wind speed and the cut-out wind speed. As power control, this can be said to be a sort of active stall.

Furthermore, it has a tower made out of laminated wood covered by fiberglass laminate. From the start the tower was free standing, but after two years it was complemented with support from three guy-wires. The construction may therefore be described as semi-guy wired. The guy wires were added because small fatigue cracks appeared in some of the glue joints attaching the steel flanges to the glue laminated wood. This is a critical teething problem, as the steel flanges fasten the wood tower to the foundation, which is not intrinsic to the wood tower but rather an effect of bad selection of glue. The problem has been solved and tested by Vertical Wind AB but the solution has not been fitted to the T1-tower for logistic reasons, it would involve the full disassembly of tower and turbine. After adding the guy-wires a new upper limit of the rotational speed was set to 22 rpm. The reason for this is that the added guy-wires stiffens the tower so that the first mode Eigen frequency of the tower is excited at 23 rpm. The T1-turbine is a first prototype and the noise level was not considered during design. If commercially produced, means to minimize noise would probably be taken, for example by altering the blade shape and choosing a blade profile developed to minimize noise rather than the standard blade profiled used for the T1-turbine. The turbine is operated from a substation situated 60 m away and wind speed is measured at a mast 100 m from the turbine. The turbine can also be fully operated by remote desktop.

1.3. Aim of thesis:

The work in this thesis aims to take a closer look at the Eigen frequencies of a semi-guywires wind turbine tower as well as the characteristics of the noise emitted from a VAWT. This should be done by performing theoretical and analytical studies as well as computer simulations and experiments. Work could for example lead to usable analytical expressions, highlighting of concept characteristics and drawn conclusions for future turbine design. In this thesis, the theory, results and conclusions is presented in such a way that the scientific contribution is pointed out. The purpose for studying the VAWT concept is to better understand its future chances of being an alternative to HAWTs. Further learning of the advantages and disadvantages of the concept can also help to find application areas that are especially suitable for VAWTs. Also, by drawing knowledge from existing VAWTs, the possibilities for building well-functioning turbines in the future increases.

1.4. Survey of OPERA Textile Mill

During my visit to the OPERA Textile Mill, I had the privilege to interview Muhammad Siddiq a General Manger responsible for the facility's operations and maintenance. Siddiq provided valuable insights into OPERA's power generation methods and emphasized the company's commitment to environmentally friendly and efficient electricity production.

According to Siddiq, OPERA generates electricity through a combination of gas turbines and steam turbines. Natural gas serves as the primary fuel source for the gas turbines, while the steam turbines are powered by the waste heat generated from the gas turbines. This combined cycle configuration significantly enhances overall efficiency and resource utilization, resulting in a more sustainable and environmentally conscious electricity generation process.

Siddiq also highlighted OPERA's strong focus on environmental sustainability and their desire to explore greener energy solutions. The company actively considers the integration of renewable energy technologies, such as solar and wind power, into their power generation portfolio. By embracing these clean energy sources, OPERA aims to reduce greenhouse gas emissions and minimize their environmental footprint.

Efficiency is a top priority for OPERA, and Siddiq discussed their ongoing efforts to optimize plant performance. This includes regular equipment monitoring, proactive maintenance practices, and a commitment to minimizing downtime. Additionally, OPERA consistently invests in technological advancements to improve the efficiency of their power generation processes, allowing them to maximize output while minimizing resource consumption.

In conclusion, my conversation with Muhammad Siddiq revealed OPERA's steadfast dedication to generating electricity in an environmentally friendly and efficient manner. Their adoption of a combined cycle configuration and their willingness to explore renewable energy sources demonstrate their commitment to sustainable power generation. By prioritizing environmental considerations and striving for efficiency improvements, Siddiq aims to contribute to a greener and more sustainable energy landscape.

Figure 1: OPERA Facebook Logo

1.5. Components Selection

We made a list of all the components that would be required for our project and started going through the different components and their alternatives that were available in the market.

1.5.1. Generator

Generators work by rotating a coil of wire in a magnetic field, which causes a current to flow through the wire. A generator can be a huge rotating turbine powered by water, wind, steam, gas or nuclear reactions that sends electricity through power lines to thousands of customers. But normally, when we use the word, we think of a small gasoline or diesel-powered machine you might have in your basement for when a storm knocks out your power to create electricity right before your eyes. A special kind of generator called an alternator powers the car's electrical system (including its lights, power steering, etc.) while it's driving.

We use generator which gives output 6-12 volts and 0.5mA. And this generator connected with wind turbine.

Figure 2: Alternator

1.5.2. Solar panel:

A Solar panel (also known as "PV panels") is a device that converts light from the sun, which is made up of particles of energy called "photons", into electricity that can be used to power electrical appliances.

Solar panels can be used for a wide variety of applications, including remote power systems for cabins, telecommunications equipment, remote sensing, and of course for the generation of electricity by residential and commercial solar electric systems.

On this page we will discuss the history, technology and benefits of solar panels. We will learn how solar panels work, how they are made, how they generate electricity and where you can buy solar panels. We use 40 watts monocrystalline solar plate which gives 20 to 22% efficiency.

Figure 3: Solar Panel

1.5.3. Relay:

A relay is a simple electromechanical switch. While we use regular switches to manually close or open a circuit, a relay is also a switch that connects or disconnects two circuits. But instead of manually controlling the relay, it uses an electrical signal to control an electromagnet, which in turn connects or disconnects another circuit.

Relays can be of different types, such as electromechanical, solid state. Electromechanical relays are often used. Let's look at the internals of this relay before we know it works. Although many different types of relays have been present, their function is the same.

Each electromechanical relay consists of one

Electromagnet

Mechanically movable contact

Switch points a

Spring

An electromagnet is constructed by winding a copper coil on a metal core. The two ends of the coil are connected to the two pins of the relay as shown. These two are used as DC power pins. We use relay in this project to change wind to solar and solar to wind with respect to sunlight and wind conditions.

Figure 4: Relay

1.5.4. Inverter:

An inverter converts direct current to alternating current. In most cases, the DC input voltage is usually lower, while the AC output voltage is equal to the mains supply voltage of either 120 volts or 240 volts depending on the country.

The inverter can be built as a stand-alone device for applications such as solar power, or work as a backup source from batteries that are charged separately.

Another configuration is when it is part of a larger circuit such as a power supply unit or UPS. In this case, the inverter's DC input is from the rectified AC mains in the PSU, while it is either from the rectified AC in the UPS when the power is on, and from the batteries whenever there is a power failure.

There are different types of converters according to the shape of the switching waveform. These have different circuit configurations, efficiencies, advantages and disadvantages

An inverter provides AC voltage from DC sources and is useful for powering electronics and electrical equipment rated for AC mains voltage. In addition, they are widely used in inverting stages of switching power supplies. Circuits are classified by switching technology and switch type, waveform, frequency, and output waveform.

We use inverter which input is 3-12 volts DC and its output is 50 watts AC, and its purpose to convert volts to AC that come from Plate and wind turbine.

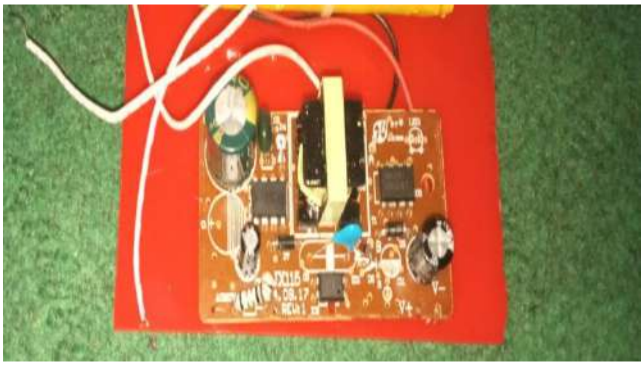

Figure 5: Inverter

1.5.5. Buck-Boost Convertor:

The buck–boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a fly back converter using a single inductor instead of a transformer.[1] Two different topologies are called buck–boost converter. Both of them can produce a range of output voltages, ranging from much larger (in absolute magnitude) than the input voltage, down to almost zero.

In the inverting topology, the output voltage is of the opposite polarity than the input. This is a switched-mode power supply with a similar circuit topology to the boost converter and the buck converter. The output voltage is adjustable based on the duty cycle of the switching transistor. One possible drawback of this converter is that the switch does not have a terminal at ground; this complicates the driving circuitry. However, this drawback is of no consequence if the power supply is isolated from the load circuit (if, for example, the supply is a battery) because the supply and diode polarity can simply be reversed. When they can be reversed, the switch can be on either the ground side or the supply side.

We use buck converter to increase watts of wind turbine. Its input is 12 watts and output is 40 to 50 watts.

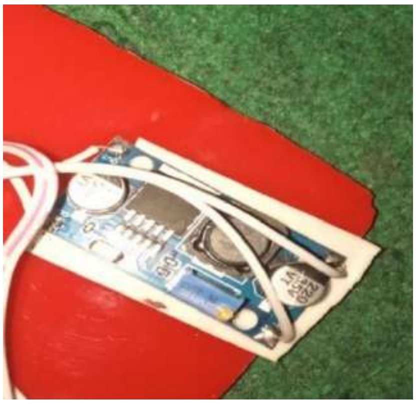

Figure 6: Buck Booster

1.5.6. Coupler:

In electronics, electricity and telecommunications, coupling is the transfer of electrical energy from one circuit to another or between parts of a circuit. Coupling may be intentional as part of the circuit's function or it may be undesirable, for example due to coupling to stray fields. For example, energy is transferred from a power source to an electrical load by means of a conductive coupling, which can be either resistive or direct. An AC potential can be transferred from one segment of a circuit to another that has a DC potential by means of a capacitor. Electrical energy can be transferred from one segment of a circuit to another segment with different impedance using a transformer; this is known as impedance matching. These are examples of electrostatic and electrodynamics inductive coupling.

Figure 7: Coupler

1.5.7. LED:

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it. When current passes through the LED, electrons recombine with holes emitting light in the process. LEDs allow current to flow in the forward direction and block current in the reverse direction. Light emitting diodes are heavily doped p-n junctions. Based on the semiconductor material used and the amount of doping, the LED will emit colored light at a specific spectral wavelength when forward-directed. As shown in the figure, the LED is encapsulated by a transparent cover so that the emitted light can come out.

We use 40 Watts LED which operate on wind and solar voltages.

Figure 8: LED

1.5.8. Pulleys:

It is a simple wooden or metal machine that uses a wheel and rope to lift heavy loads. Nowadays, plastic pulleys are also available in the market for carrying small loads. It can be freely rotated around an axis passing through its center. It can change the direction of force, making it easier for people to lift anything. Thanks to this, you can pull on one end and lift a 10 kg and one meter high object.

1.5.9. Types of pulleys:

Fixed pulley:

When a pulley block is fixed on a high platform, it is known as fixed. A stretchable cord passes through a slot where one end is attached to the body to be lifted while the other end is free.

Movable pulley:

When the pulley block is not fixed but carries a load, it is called movable. An inextensible cord is tied around the groove, one end of which is attached to a fixed support, while the other end is left free to allow effort to be exerted. When force is applied, the block moves up with the load.

Pulley Formula:

Following are the formulas that are used when pulleys are used for lifting. There are formulas that are important and they are:

Using a single formula inside the triangle, mechanical advantage, load, and effort can be generated.

- Mechanical advantage = (Load/Effort)
- Load = Mechanical advantage*Effort
- Effort = (Load/Mechanical advantage)
- Velocity ratio: It is defined as the ratio of the distance moved by the effort to the distance moved by the load.

Using a single formula inside the triangle, distance moved by the load, velocity ratio, and distance moved by the load can be generated.

- Distance moved by load = (distance moved by effort/Velocity ratio)
- Velocity ratio = (distance moved by effort/Distance moved by load)

- Distance moved by effort = Distance moved by the load*Velocity ratio
- We use lower pulley in this project is 5 inches and connected with generator through belt.

Figure 9: Gear Pulley

1.5.10. Belt:

As a source of motion, a conveyor belt is one application where the belt is adapted to continuously carry a load between two points A belt is a loop of flexible material used to mechanically connect two or more rotating shafts, most often parallel. Belts can be used as a source of motion, for efficient energy transfer, or for tracking relative motion. The belts are wrapped over the pulleys and can twist between the pulleys and the shafts do not have to be parallel.

In a two-pulley system, the belt can either drive the pulleys normally in one direction (same as on parallel shafts), or the belt can be crossed so that the direction of the driven shaft is reversed (opposite to the driver). if on parallel shafts). A belt drive can also be used to change the speed of rotation, either up or down, using different sized pulleys.

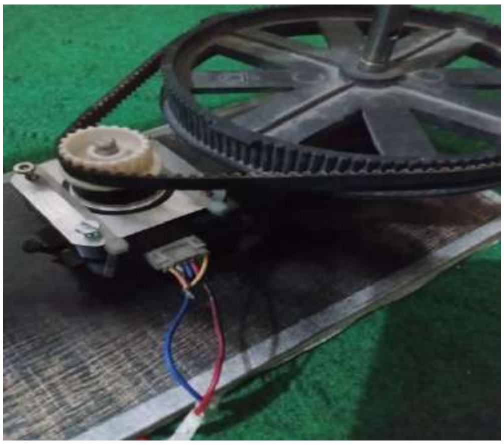

Figure 10: Belt

1.5.11. Steel and Aluminum Rods:

We use steel rod from bearings to blades and this steel rod is 12 inches and we use aluminum rod which connected with blades are 8 inches from center to blade.

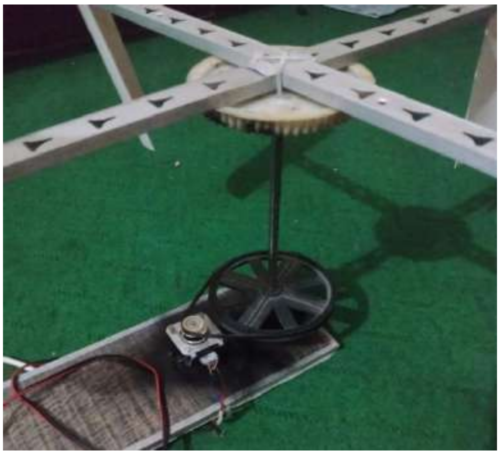

Figure 11: Rod

1.5.12. Bearing:

A bearing is a machine element that limits relative motion to only the desired motion and reduces friction between moving parts. For example, the design of the bearing can ensure free linear movement of the movable part or free rotation about a fixed axis; or it can prevent motion by controlling the normal force vectors that act on the moving part. Most bearings facilitate the desired movement by minimizing friction. Bearings are broadly classified according to the type of operation, the movements allowed, or the directions of the loads (forces) acting on the components.

Slewing bearings hold rotating components such as shafts or axles in mechanical systems and transfer axial and radial loads from the load source to the supporting structure. The simplest form of bearing, the plain bearing, consists of a shaft rotating in a hole. Lubrication is used to reduce friction. Lubricants come in a variety of forms, including liquids, solids, and gases. The choice of lubricant depends on the specific application and factors such as temperature load and speed. In a ball and roller bearing, rolling elements such as rollers or balls with a circular cross-section are placed between the rings or pins of the bearing assembly to reduce sliding friction. There is a wide variety of bearing designs that allow the application requirements to be properly met for maximum efficiency, reliability, life and performance.

We use two bearings which fix in wood piece and both bearings are 6mm.

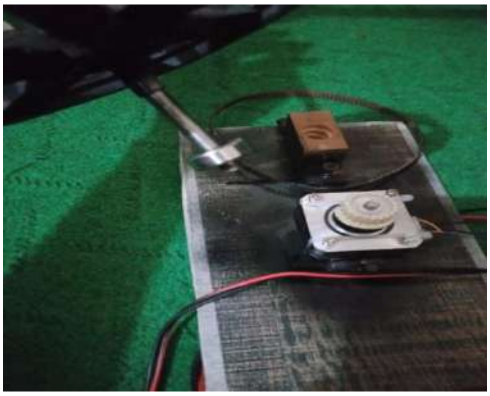

Figure 12: Upper Bearing

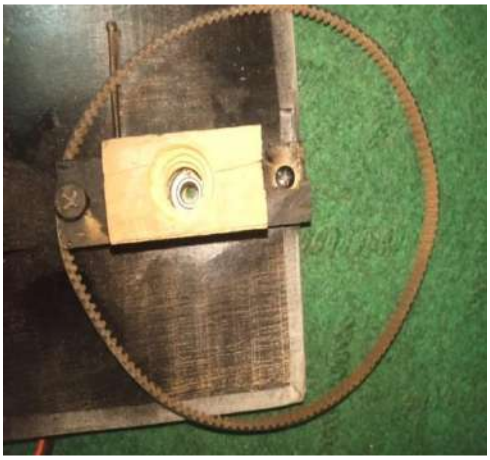

Figure 13: Lower Bearing

1.5.13. PVC Blades:

We use four blades which make from PVC pipe as shown in figure.

Figure 14: PVC Blades

Specifications of Blades:

Length of blades is 1 feet.

Width of blades is 3/12 inches.

Shape is curved.

1.5.14. Wires:

Wires are pieces of metal that carry electricity. They are usually flexible, which makes them easy to use. These electrical wires are crucial to all electrical devices, from the electrical circuit board in a computer to the transformer in the neighborhood or even the electrical transmission system carrying electricity hundreds of kilometers. Without wires, electricity would be unavailable to everyone, making them an essential part of modern life. Depending on their purpose, wires can have different sizes and compositions.

1.5.16. Battery:

A lithium-ion or Li-ion battery is a type of rechargeable battery which uses the reversible reduction of lithium ions to store energy. The negative electrode of a conventional lithium-ion cell is typically graphite, a form of carbon. This negative electrode is sometimes called the anode as it acts an anode during discharge. The positive electrode is typically a metal oxide; the positive electrode is sometimes called the cathode as it acts a cathode during discharge. Positive and negative electrodes remain positive and negative in normal use whether charging or discharging and are therefore clearer terms to use than anode and cathode which are reversed during charging.

Figure 15: Lithium Cell

1.5.17. Volt and Ampere meter:

Instrument for measuring either direct (DC) or alternating (AC) electric current, in amperes. An ammeter can measure a wide range of current values because at high values only a small portion of the current is directed through the meter mechanism; a shunt in parallel with the meter carries the major portion. In circuit diagrams, the symbol for an ammeter is a circle with a capital A inside. Ammeters vary in their operating principles and accuracies. The D'Arsonval-movement ammeter measures direct current flowing through a coil suspended between the poles of a magnet with accuracies of from 0.1 to 2.0 percent. The electrodynamics ammeter uses a moving coil rotating in the field produced by a fixed coil. It measures direct and alternating current (by using a rectifier to convert the AC to DC) with accuracies of 0.1 to 0.25 percent. In the thermal (or hot-wire) ammeter, used primarily to measure AC with accuracies of 0.5 to 3 percent, the measured current heats a piece of wire, and the current is indicated by how much the wire expands. Digital ammeters, with no moving parts, use a circuit such as the dual slope integrator to convert a measured analog (continuous) current to its digital equivalent. Many digital ammeters have accuracies better than 0.1 percent.

A voltmeter is an instrument used for measuring electric potential difference between two points in an electric circuit. It is connected in parallel. It usually has a high resistance so that it takes negligible current from the circuit.

Analog voltmeters move a pointer across a scale in proportion to the voltage measured and can be built from a galvanometer and series resistor. Meters using amplifiers can measure tiny voltages of microvolts or less. Digital voltmeters give a numerical display of voltage by use of an analog-to-digital converter.

Voltmeters are made in a wide range of styles, some separately powered (e.g. by battery), and others powered by the measured voltage source itself. Instruments permanently mounted in a panel are used to monitor generators or other fixed apparatus. Portable instruments, usually equipped to also measure current and resistance in the form of a millimeter, are standard test instruments used in electrical and electronics work. Any measurement that can be converted to a voltage can be displayed on a meter that is suitably calibrated; for example, pressure, temperature, flow or level in a chemical process plant.

General-purpose analog voltmeters may have an accuracy of a few percent of full scale and are used with voltages from a fraction of a volt to several thousand volts. Digital meters can be made with high accuracy,

typically better than 1%. Specially calibrated test instruments have higher accuracies, with laboratory instruments capable of measuring to accuracies of a few parts per million. Part of the problem of making an accurate voltmeter is that of calibration to check its accuracy. In laboratories, the Weston cell is used as a standard voltage for precision work. Precision voltage references are available based on electronic circuits.

Figure 16: Volt and Ampere meter

1.5.18. Green Capacitors:

Photovoltaic (PV) cell arrays represent the most common type of solar power generation. The cells produce power by pulling or "knocking" electrons loose from absorbed solar energy, to create an electron flow that is captured as dc current. The dc power is converted to ac via inverters. The inverter technology may be in the form of either a single micro inverter connected to each solar panel or a string inverter, which converts the accumulated power of multiple solar panels, wired in a series configuration. Within each inverter, film capacitors or long-life electrolytic find use in the dc link, snobbier and ac output filters. One of the fastest growing sectors of the PV solar market is "off-grid power." Off-grid power setups are entirely self-sufficient solar-powered supplies for lighting, remote monitoring and other applications. For example, a remote parking lot can be lit by high-efficiency LED lights and powered by solar without any connection to a power grid. This application usually employs micro inverters. Another type of solar power generation is a solar furnace, which concentrates sunlight on a focal point. Temperatures at that focal point can reach 3,500°C and provide a means to power a steam–powered ac generator, as in a conventional power plant. To operate the solar furnace at maximum efficiency, the mirrors that redirect the sunlight must constantly be repositioned. Electric motors, powered by rechargeable batteries or super capacitors, handle the repositioning.

A key benefit of solar furnace technology is that its use of time-tested steam power generators makes it safe and clean – it releases no pollutants, even in a disaster. France is home to the largest solar furnace power station at Odeillo. It covers about 2,000 m^2. Most are considerably smaller. Wind turbines have a pitch system that adjusts the angle of the props depending on wind conditions. The pitch-control system may be hydraulic or electric though the majorities are electric. Here, electric motors powered by batteries or super capacitor modules alter the pitch angle. It's well known that the performance of rechargeable batteries degrades with a rising number of charge/discharge cycles. Additionally, batteries may lose capacity in cold weather and experience reduced lifespans when it's hot. Published literature suggests that prop-pitch batteries need replacement about every five years. Unlike batteries, super capacitors don't degrade much with each charge/discharge cycle. A significant additional benefit is that they should last two to four times longer than battery packs, reducing long-term service costs. Supercapacitor arrays are already in use by major wind power manufacturers, demonstrating the attractiveness of this approach.

Figure17: Green Capacitor

Chapter 2:

Literature Review:

Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity. A wind turbine used for charging batteries may be referred to as a wind charger. The result of over a millennium of windmill development and modern engineering, today's 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 small 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 renewable energy and are used by many countries as part of a strategy to reduce their reliance on fossil fuels. So how do wind turbines make electricity? Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. They do not require as much wind to generate power, thus allowing them to be closer to the ground where wind speed is lower. By being closer to the ground they are easily maintained and can be installed on chimneys and similar tall structures.

2.1. Niranjana.S.J:

Investigated the power generation by vertical axis wind turbine. In this paper the power is generated by fixing the wind mill on the road high ways .when the vehicle is passed through the road at high speed the turbine of the wind mill rotates and generates the power sources. This analysis indicates that the vertical axis wind turbine can be able to attain the air from all the direction and produces the power of 1 kilowatt for a movement of 25 m/s. The efficiency of vertical axis wind turbine can be increases by modifying the size and shape of the blade.

2.2. Abmjit N Roy et al:

Analyzed the design and fabrication of vertical axis economical wind mill. This paper indicates that vertical axis wind mill is one of the most important types of wind mill. In this main rotor shaft is connected to the wind turbine vertically with the generator and gear box which can be placed near the ground. Performance characteristics such as power output versus wind speed or versus angular velocity must be optimized in order to compete with other energy sources which make the process economically and eco-friendly. The experimental result shows that wind turbine is placed on the top of the building in an ideal position to produces electricity. The power generation becomes easy and it is used for various applications such as street light, domestic purpose, agriculture etc.

2.3. D.A. Nikam et al:

Analyzed the literature review on design and development of vertical axis wind turbine blade. This paper explains that the wind mill such as vertical and horizontal wind mill is widely used for energy production. The horizontal wind mill is highly used for large scale applications which require more space and huge investment. Whereas the vertical wind mill is suitable for domestic application at low cost. The generation of electricity is affected by the geometry and orientation of the blade in the wind turbine. To optimize this by setting the proper parameter for the blade design. The experimental result indicates that the blade plays critical role in the performance and energy production of the turbine. The optimized blade parameter and its specification can improve the generation of electricity.

2.4. Altab Hossain et al:

Investigated the design and development of A 1/3 scale vertical axis wind turbine for electrical power generation. In this paper the electricity is produce from the wind mill by wind power and belt power transmission system. The blade and drag devices are designed in the ratio of 1:3 to the wind turbine. The experiment is conducted by different wind speed and the power produced by the windmill is calculated. The experimental result indicates that 567 W powers produced at the speed of 20 m/s while 709 W power produced at the speed of 25 m/s. From this, the power productions will increases when the velocity is high.

2.5. M. Abid et al:

Analyzed the design, development and testing of a savonius and darrieus vertical axis wind turbine. This paper shows that vertical axis wind mill is more efficient when compare to horizontal axis wind mill. The darrieus turbine consists of 3 blades which can start alone at low wind speed. When savonius turbine is attached on the top of existing wind mill which provide the self-start at low wind speed. The result indicates that the darrieus vertical axis wind turbine acts as a self-starter during the testing. The function required the starting mechanism which can be provided by the combination of NACA 0030 aero foil and savonius turbine. The high blade thickness of the NACA 0030 aero foil will improves the self-starting capability of the turbine.

2.6. ParthRathod et al:

Analyzed a review on combined vertical axis wind turbine. In this paper, the increased efficiency is achieved based on the characteristics such as aspect ratio, tip speed ratio, velocity and other geometry parameter. The experiment is conducted to increase the power production and efficiency of a wind turbine. The development of design is optimized by combining the blade structure and the flow performance. The result indicates that the efficiency of turbine is always based on the wind speed and climatic conditions. The lowest aspect ratio improves the power coefficient of the turbine. The power generation of combined rotor is high compare to the single savonius and darrieus rotor.

2.7. KunduruAkhil Reddy et al:

Investigated a brief research, study, design and analysis on wind turbine. This paper evaluates the aerodynamic performance of variable speed fixed pitch horizontal axis wind turbine blade using two and three dimensional computational fluid dynamics. The primary objective of the paper is to increases the aero dynamic efficiency of a wind turbine. The blades are designed using different type of airfoils which are associated with angle of attack. The blade design is responsible for the efficiency of the wind turbine. The design of the blade is done using Q- blade software. The result indicates that the power output is determined using blade elemental theory. The power output of designed blade design is higher when compare to existing design of the blade.

2.8. Piyush Gulve et al:

Analyzed the design and construction of vertical axis wind turbine. This paper indicates that vertical axis wind turbine is more efficient than horizontal axis wind turbine because it requires compact space for producing same amount of electricity and less noise. The result of the paper indicates that the efficiency of wind turbine may reduce due to manufacturing error and frictional losses. It will be rectified by précising the design of the blade more aerodynamically. From the above literature review, it is clearly understood that the efficiency of wind turbine is always based on the parameters such as design and size of the blade, aspect ratio, tip speed ratio, blade angles and velocity. The power production of combined vertical and horizontal wind mill is high compare to vertical axis wind turbine and horizontal axis wind turbine. It requires less space for high generation of electricity.

2.9. Purpose Analysis:

The last decade has witnessed significant advances in energy harvesting technology for the realization of self-charging electronics and self-powered wireless sensor nodes (WSNs). To conquer the energy-insufficiency issue of a single energy harvester, hybrid energy harvesting systems have been proposed in recent years. Hybrid harvesting includes not only scavenging energy from multiple sources, but also converting energy into electricity by multiple types of transduction mechanisms. A reasonable hybridization of multiple energy conversion mechanisms not only improves the space utilization efficiency but can also boost the power output significantly. Given the continuously growing trend of hybrid energy harvesting technology, herein we present a comprehensive review of recent progress and representative works, especially focusing on vibrational and thermal energy harvesters which play the dominant role in hybrid energy harvesting. The working principles and typical configurations for piezoelectric, electromagnetic, turboelectric, thermoelectric and pyro electric transduction effects are briefly introduced. On this basis, a variety of hybrid energy harvesting systems, including mechanisms, configurations, output performance and advantages are elaborated. Comparisons and perspectives on the effectiveness of hybrid vibrational and thermal harvesters are provided. A variety of potential application prospects of the hybrid systems are discussed, including infrastructure health monitoring, industry condition monitoring, smart transportation, human healthcare monitoring, marine monitoring systems, and aerospace engineering, towards the future Internet-of-Things (IoT) era.

Chapter 3

Analysis:

3.1. Rotation Ratio:

The rotation ratio is

Main gear one turn is equal to 10 turns of generator.

3.2. Conversion formulas for volts, amperes and watts:

Watts to volts formula:

DC volts $V_{(V)} = P_{(W)} / I_{(A)}$

Single phase volt formula:

$V_{(V)} = P_{(W)} / (PF \times I_{(A)})$

DC(volts)=P(w)/I(A)

DC(volts)= 40/3.33

DC(volts)= 12.0 volts

AC(volts)= 12.0 volts

Power factor=1

Amperes to watts formula:

DC amps to watts calculation:

$P_{(W)} = I_{(A)} \times V_{(V)}$

AC single phase amps to watts calculation:

$P_{(W)} = PF \times I_{(A)} \times V_{(V)}$

P(w)=I(A)*V

P(w)= 3.33*12

P(w)= 39.96 watt

=39960 mW

=0.03996 KW4

On AC:

P(w)= 39.96 watt

Power factor = 1

Volts to amperes formula:

$I_{(A)} = P_{(W)} / V_{(V)}$

With resistance:

$I_{(A)} = V_{(V)} / R_{(\Omega)}$

I(A)=p(w)/V

I(A)= 40/12

I(A)= 3.33 A

Volts to watts formula:

DC volts to watts calculation formula:

The power *P* in watts (W) is equal to the voltage *V* in volts (V), times the current *I* in amps (A):

$P_{(W)} = V_{(V)} \times I_{(A)}$

AC single phase volts to watts calculation formula:

The power *P* in watts (W) is equal to the power factor *PF* times the phase current *I* in amps (A), times the RMS voltage *V* in volts (V):

$P_{(W)} = PF \times I_{(A)} \times V_{(V)}$

P(w)= V * I

P(w)= 12 * 3.33

P(w)= 39.96 watt

On AC single phase:

P(w)= PF * V * I

P(w)= 39.96 watt

Power Factor:

Direct current has no power factor because it is accompanied by zero frequency. For alternating current voltages, power factor is a norm and ranges between zero and one, where one is the perfect system, and zero is the bad system. Power factor is only related to the AC circuit.DC circuit will not have power face since there is zero frequency and phase angle difference between current and voltage. Power Factor is given by the cosine of the angle between voltage and current.

$P = VI \cos\theta$

Rearranging the above formula we get

$\cos\theta = P/VI$

Therefore,

Cosθ = True Power/Apparent Power

Where,

Cosθ = Power factor

P = Power in Watts

V = Voltages in Volts

I = Current in Amperes

The true power is given in terms of Watts and the Apparent power is given in terms of Volt-Amperes or Watts

The power factor in an AC circuit is also given by the ratio of Resistance and Impedance

$\cos\theta = R/Z$

Where,

R = Resistance in ohms

Z = Impedance

Impedance (Z) is the total resistance in the AC circuit and is given by

$Z=\sqrt{[R^2+(X_L+X_c)^2]}$

Where,

R = resistance

X_L =inductive reactance

X_c = capacitive reactance

Here, it is noted that single-phase power factor is less than 1.

Note: For a purely resistive circuit, the power factor is 1.

For purely resistive loads, such as heaters, or light bulbs, the power factor equals 1.0. For inductive or capacitive loads like motors, the power factor is less than 1.0 and must be determined by actually measuring it or from the nameplate of the device.

3.3. Derivation and calculations for air pressure:

''Air is fluid and to discuss the air pressure in center of road we use fluid dynamics''

Fluid dynamics refers to a sub-discipline of fluid mechanics that revolves around fluid flow in motion. Furthermore, fluid dynamics comprises of some branches like aerodynamics and hydrodynamics. Fluid dynamics involves the calculation of various fluid properties, such as flow velocity, pressure, density, and temperature, as functions of space and time.

Fluid dynamics offers a systematic structure to the practical disciplines that depend on the flow measurement. Furthermore, it helps in the derivation of empirical and semi-empirical laws. As such, fluid dynamics facilitate the solving of practical problems.

The fluid dynamics applications include understanding nebulae in interstellar space, predicting weather patterns, calculating force and moments on aircraft, determining the mass flow rate of petroleum through pipelines, and modeling fission weapon detonation.

3.4. How do we Measure Fluid Dynamics?

In order to solve fluid dynamics problems, use of three conservation laws takes place. Furthermore, one can write these laws in an integral or differential form. Moreover, the application of these conservation laws may be to a control volume, a region of the flow. A control volume is a discrete volume in space via which one can assume the fluid to flow. Furthermore, experts use the integral formulations of the conservation laws to describe the change of energy, mass, or momentum, within the control volume. Also, there is an application of the Stokes' theorem by differential formulations of the conservation laws to yield an expression. The interpretation of this expression can be as the integral form of the law that is applied to an infinitesimally small volume within the flow. To an extent, all fluids can be said to be compressible. Moreover, this means that a change in temperature or pressure will result in a change in density. However, the changes in temperature and pressure, in most cases, are quite small such that the changes in density turn out to be negligible. In this case, the modeling of the flow can take place as an incompressible flow. Otherwise, one must make use of the more general compressible flow equations.

3.5. Formula of Fluid Dynamics:

Equations in Fluid Dynamics: Bernoulli's Equation

$P/\rho + gz + v^2 = k$

$P/\rho g + z + v^2/2g = k$

$P/\rho g + v^2/2g + z = k$

Here,

$P/\rho g$ is the pressure head or pressure energy per unit weight fluid

$v^2/2g$ refers to the kinetic head or kinetic energy per unit weight

z over here is the potential head or potential energy per unit weight

P is certainly the Pressure

ρ is the Density

K is the Constant

The Bernoulli equation happens to be different for isothermal and adiabatic processes.

$dP/\rho + VdV + gdZ = 0$

Also, $\int(dP/\rho + VdV + gdZ) = K$

$\int dP/\rho + V^2/2 + gZ = K$

Where,

Z is the elevation point

ρ is the density of the fluid

One can also write the equation as,

$q + P = Po$

Where,

q is the dynamic pressure

P_O is the total pressure

P is the static pressure

Derivation of the Formula of Fluid Dynamics

Consider a pipe with varying height and diameter via which the flowing of an incompressible fluid takes place. Furthermore, the relationship here is between the areas of cross-sections A, pressure p, the flow speed v, and the height from the ground y, at two different points 1 and 2.

3.6. Assumptions:

- The density of the incompressible fluid would always remain constant at both points.
- There is a conservation of energy of the fluid due to a lack of viscous forces in the fluid.

Therefore, the work taking place on the fluid is given as:

$dW = F_1dx_1 – F_2dx_2$

Also, $dW = p_1A_1dx_1 – p_2A_2dx_2$

So, dW will be $= p_1dV – p_2dV = (p_1 – p_2)dV$

An important point to remember here is that the work taking place on the fluid is because of the change in kinetic energy and conservation of gravitational force. Moreover, the expression of the change in the fluid's kinetic energy is as:

dK = 12m2v22–12m1v21=12pdV(v22–v21)

The change in potential energy is expressed as:

$dU = mgy_2 – mgy_1$, which will be $= \rho dVg(y_2 – y_1)$

Therefore, the energy equation is expressed as:

$dW = dK + dU$

$(p_1 – p_2)dV$ = 12pdV(v22–v21)

$+ \rho dVg(y_2 – y_1)$

$(p_1 – p_2)$ = 12p(v22–v21)

$+ \rho g(y_2 – y_1)$

Finally, on facilitating a rearrangement of the above equation, we get

p1+12pv21+pgy1=p2+12pv22+pgy2

Most noteworthy, this is Bernoulli's equation.

3.7. Surface Pressure:

Surface pressure is the atmospheric pressure at a location on Earth's surface (terrain and oceans). It is directly proportional to the mass of air over that location.

For numerical reasons, atmospheric models such as general circulation models (GCMs) usually predict the no dimensional logarithm of surface pressure.

The average value of surface pressure on Earth is 985 hPa. This is in contrast to mean sea-level pressure, which involves the extrapolation of pressure to sea level for locations above or below sea level. The average pressure at mean sea level (in the International Standard Atmosphere (ISA) is 1,013.25 hPa, or 1 atmosphere (atm), or 29.92 inches of mercury.

3.8. Fluid dynamics on road:

That if car moves on road than it creates pressure in center of road and on train track when train move than pressure produce that pull everything towards train in this way when on two way road cars move with speed then pressure of air increase on divider between roads so this air pressure used to rotate the vertical axis wind turbines.

Figure 18: VAWT

Barometric Formula:

3.9. Pressure Equations:

$$P = P_b \left[\frac{T_b - (h - h_b) L_b}{T_b} \right]^{\frac{g_0 M}{R^* L_b}}$$

The second equation is applicable to the standard model of the stratosphere in which the temperature is assumed not to vary with altitude:

$$P = P_b \exp\left[\frac{-g_0 M (h - h_b)}{R^* T_b} \right]$$

where:

- P_b = reference pressure
- T_b = reference temperature (K)
- L_b = temperature lapse rate (K/m) in ISA
- h = height at which pressure is calculated (m)
- h_b = height of reference level b (meters; e.g., h_b = 11 000 m)
- R^* = universal gas constant: 8.3144598 J/(mol·K)
- g_0 = gravitational acceleration: 9.80665 m/s^2
- M = molar mass of Earth's air: 0.0289644 kg/mol

Or converted to imperial units:[1]

where:

- P_b = reference pressure
- T_b = reference temperature (K)
- L_b = temperature lapse rate (K/ft) in ISA
- h = height at which pressure is calculated (ft)
- h_b = height of reference level b (feet; e.g., h_b = 36,089 ft)
- R^* = universal gas constant; using feet, kelvins, and (SI) moles: 8.949 4596 × 10^4 lb·ft^2/(lb-mol·K·s
- g_0 = gravitational acceleration: 32.17405 ft/s^2
- M = molar mass of Earth's air: 28.9644 lb/lb-mol

Figure 19: Pressure Equation

Equation 1:

$$\rho = \rho_b \left[\frac{T_b - (h - h_b) L_b}{T_b} \right]^{\left(\frac{g_0 M}{R^* L_b} - 1 \right)}$$

which is equivalent to the ratio of the relative pressure and temperature changes

$$\rho = \rho_b \frac{P}{T} \frac{T_b}{P_b}$$

Equation 2:

$$\rho = \rho_b \exp \left[\frac{-g_0 M (h - h_b)}{R^* T_b} \right]$$

where

- ρ = mass density (kg/m^3)
- T_b = standard temperature (K)
- L = standard temperature lapse rate (see table below) (K/m) in ISA
- h = height above sea level (geopotential meters)
- R^* = universal gas constant 8.3144598 N·m/(mol·K)
- g_0 = gravitational acceleration: 9.80665 m/s^2
- M = molar mass of Earth's air: 0.0289644 kg/mol

or, converted to U.S. gravitational foot-pound-second units (no longer used in U.K.)

- ρ = mass density (slug/ft^3)
- T_b = standard temperature (K)
- L = standard temperature lapse rate (K/ft)
- h = height above sea level (geopotential feet)
- R^* = universal gas constant: 8.9494596×10^4 ft^2/(s·K)
- g_0 = gravitational acceleration: 32.17405 ft/s^2
- M = molar mass of Earth's air: 0.0289644 kg/mol

Figure 20: Height above Sea

Derivation:

The barometric formula can be derived using the ideal gas law:

$$P = \frac{\rho}{M} R^* T$$

Assuming that all pressure is hydrostatic:

$$dP = -\rho g\, dz$$

and dividing the dP by the P expression we get:

$$\frac{dP}{P} = -\frac{M g\, dz}{R^* T}$$

Integrating this expression from the surface to the altitude **z** we get:

$$P = P_0 e^{-\int_0^z M g dz / R^* T}$$

Assuming linear temperature change $T = T_0 - Lz$ and constant molar mass and gravitational acceleration, we get the first barometric formula:

$$P = P_0 \cdot \left[\frac{T}{T_0}\right]^{\frac{Mg}{R^* L}}$$

Instead, assuming constant temperature, integrating gives the second barometric formula:

$$P = P_0 e^{-Mgz/R^* T}$$

In this formulation, R^* is the gas constant, and the term $R^* T/Mg$ gives the scale height (approximately equal to 8.4 km for the troposphere).

(For exact results, it should be remembered that atmospheres containing water do not behave as an *ideal gas*. See real gas or perfect gas or gas for further understanding.)

3.10. Graph:

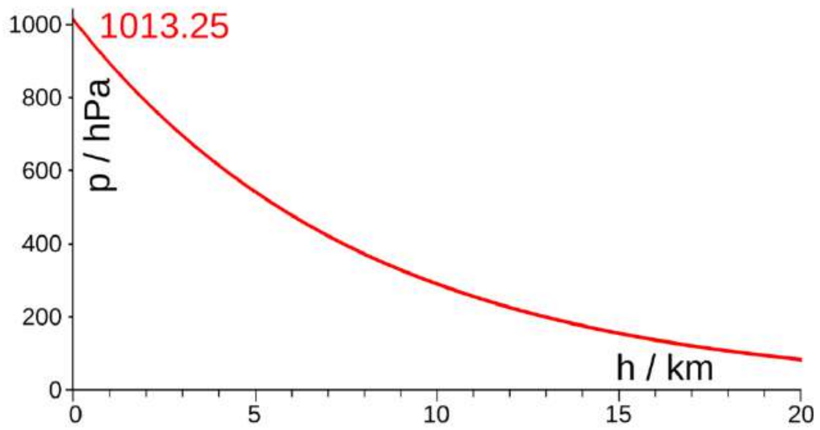

Figure 21: Pressure Graph

3.11. Atmospheric units:

For measurement of the atmospherics' absolute pressure, dedicated pressure units have been created. One of such is the standard atmosphere (atm) which is defined being 101325 Pascal. To add confusion, there is also a technical atmosphere (at) which is pretty close, but not quite the same as atm. The technical atmosphere is one-kilogram force per square centimeter. So 1 at equals about 0.968 atm.

Another pressure unit used for measuring atmospheric absolute pressure is torr, being 1/760 of standard atmosphere. So torr is an absolute pressure unit, although that is typically not mentioned, you just need to know it, which can cause confusion. Torr was initially meant to be the same as 1 millimeter of mercury, although the later definitions show a very small difference in between. Torr is not part of the SI system.

3.12. Cgs unit of pressure:

The abbreviation **"cgs"** comes from the words "**centimeter-gram-second".** As these words hint, the cgs system is a variation of the metric system, but instead of using the meter it uses centimeter as the unit for length, and instead of kilogram it uses gram as the unit for mass. Different cgs mechanical units are derived from using these cgs base units. The cgs is a pretty old system and has

been mostly replaced first by the MKS (meter-kilogram-second) system which then has been replaced by the SI system. Yet, you can still sometimes run into cgs units of pressure. The cgs base pressure unit is **barye** (Ba), which equals 1 dyne per square centimeter. Dyne is the force needed to accelerate a mass of one gram to a rate of one centimeter per second per second.
As pressure unit conversion, 1 barye (Ba) equals 0.1 Pascal (Pa).

And some more…

In addition to all the above pressure units, there are still plenty more existing… Just to mention, for example in a Beamex MC6 calibrator, there are over 40 different pressure units, plus still a few custom units for the thrill-seekers.

Pressure unit conversions standards:

If you work with pressure, you know that it is very common that pressure is indicated with a certain pressure unit and you need to convert it into another pressure unit.
Pressure units are based on standards and the conversion between units should also be based on standards.
The most common standards for pressure units are:

- SI system
- ISO31-3
- ISO 80000-4:2006
- BS350
- PTB-Mitteilungen 100 3/90
- Perry's Chemical Engineer's Handbook, 6th ed, 1984

3.13. Pressure unit converter tool:

I tried to make a conversion table between different pressure units, but that table started quickly to become a huge matrix that would not be easy for you to use at all. So instead of making a conversion table, we developed an online pressure unit converter for our website. With this converter, you can easily convert a pressure reading from one unit into other units. Please click on the link to check out the pressure unit converter.

Pressure Unit Conversion tool:

Value	Unit
10.1971621298	at
9.86923266716	atm
10	bar
10197.1621298	cmH$_2$0
10197.4476583	cmH$_2$O@4°C
10207.2522252	cmH$_2$O@60°F
10215.5419328	cmH$_2$O@68°F
750.061575846	cmHg
334.552563313	ftH$_2$0
334.561931047	ftH$_2$O@4°C
334.883603189	ftH$_2$O@60°F
335.155575224	ftH$_2$O@68°F
10197.1621298	gf/cm^2
10000	hPa
4014.63075976	inH$_2$O
4014.74317256	inH$_2$0@4°C
4018.60323827	inH$_2$0@60°F
4021.86690269	inH$_2$0@68°F
295.29983301	inHg
4014.63075976	iwc

Value	Unit
295.300267432	inHg@0°C
10.1971621298	kgf/cm^2
101971.621298	kgf/m^2
10.1971621298	kp/cm^2
1000	kPa
20885.4342332	lbf/ft^2
10000	mbar
101.971621298	mH$_2$O
7.50061575846	mHg
101971.621298	mmH$_2$O
101974.476583	mmH$_2$0@4°C
102072.522252	mmH$_2$0@60°F
102155.419328	mmH$_2$0@68°F
7500.61575846	mmHg
7500.62679277	mmHg@0°C
1	MPa
2320.60380368	ozf/in^2
1000000	Pa
145.03773773	psi
7500.61682704	torr

Figure 22: Pressure Unit Conversion

3.14. Wind speed in Islamabad:

Wind Speed in Islamabad Km/h	Wind speed in Pakistan normal Km/h	Wind speed in Islamabad m/s	Wind speed in Pakistan m/s
17	16	4.7	4.4
19	22	5.2	6.1
27	20	7.5	5.5
19	19	5.2	5.2
18	24	5	6.6

Figure 23: Wind Speed in Islamabad

3.15. Speed conversion formulas:

Km/h to m/s:

Divide the speed value by 3.6.

Mile per hour to Km/h:

Divide speed value by 1.609.

RPM Calculation:

RPM=v*TSR*60/6.28*R

V= wind speed in m/s

TSR= Tip speed ratio.

R= Radius of rotor

RPM= 60*v*TSR/3.144*D

TSR= Divide speed of tips of the turbine blades by speed of wind.

Diameter/3.14*RPM

Wind pressure= P= $0.00256*v^2$

V in miles per hour.

3.16. Pressure conversions:

Torr to Pa= Multiply pressure value by 133.3

Pa to Torr= Divide pressure value by 133.3

1 atm to Pa= Multiply pressure value by 101300

1 atm to Torr= Multiply pressure value by 760

Torr to Psi= Divide pressure value by 51.717

Pa to Psi= Divide pressure value by 6865

Torr to Mili bar= Multiply pressure value by 1.333

Pa to Mili bar= Divide pressure value by 100

Pound per square feet= PSF= Torr*2.784499

Chapter 4

Methodology & Modeling:

4.1. Vertical Axis Wind Turbine Design – VAWT Design:

A wind turbine generator (WTG) is a device that extracts kinetic energy from the wind using a rotor consisting of two or more blades that are mechanically connected to an electrical generator. But wind turbines don't have to be the stereotypical design of a tall mast with a narcel on top, they can also take the form of a Vertical Axis Wind Turbine Design or VAWT.

The energy production of a wind turbine depends on the interaction between the rotor and the wind. However, there is an upper limit to the amount of energy that can be derived from wind movement. No wind turbine can produce more electricity than the amount of energy in the wind itself. To do this, the wind turbine would have to stop the wind from blowing by extracting 100% of its kinetic energy.

The amount of energy converted by a horizontal wind turbine is proportional to the area swept by the rotor (rotor swept area). In order to capture as much of the wind's kinetic energy as possible, wind turbine blades should be as long as possible.

To increase this further, wind turbines are mounted on towers that are as tall as possible, and are most often mounted on towers that exceed 80 meters (260 ft) in height. This is because in an open, unobstructed landscape, the wind speed relative to the ground can increase greatly with increasing height above the ground.

Most modern wind turbines use a horizontal axis wind turbine or HAWT design in which the turbine blades are mounted on a horizontal shaft with the HAWT rotor blades held perpendicular to the wind flow to capture maximum energy.

This shaft is connected to a gearbox or gearbox and the gearbox is placed between the wind shaft (the axle to which the blades are attached) and the electric generator to ensure that the generator rotates at the optimum speed to produce electricity suitable for the power grid, usually in in the range of 1,200–1,800 rpm.

One disadvantage of a horizontal wind turbine generator is that in order for the rotor blades to rotate, the body of the wind turbine must continuously rotate to orient the rotor in the direction of the incoming wind.

This "yaw" control can be as simple as the tail vane on a small wind turbine generator or the more complex motor control on modern towers. However, there is another type of wind turbine design called the Vertical Axis Wind Turbine, or VAWT Wind Turbine for short, which has the advantage of receiving wind from any direction.

4.2. Turbine and power description:

The design assumed that the turbine should have a low wind speed, light and easy to move. A drag-based machine should be able to harness power from non-directional wind at a low turn-on speed, making it a better choice for many urban applications. Giant. 1a, Fig. 1b shows a view of the proposed turbine blades and support system. The vanes were attached to the hub with three steel rods and each rod is welded to the center to ensure structural stability. The blade was made of flattened trapezoidal profiled galvanized (GI) steel sheet of equal dimensions (the width of each blade

0.8 m; height of each blade

1.3 m; the angle between the cross arm

120; total height

1.5 m). 12 gauge GI sheet was chosen due to material properties viz. good tensile and compressive strength, robust, high stiffness-to-weight ratio, good corrosion resistance and durability. Mild steel is used for the hub which is connected to the main shaft. The main shaft is also made of mild steel. The shaft passes through two bearings and is connected to the generator shaft by means of a coupling arrangement. The generator stands on a wooden base that is supported by three steel rods on the ground.

The shaft is connected to an alternating permanent magnet generator (PMG) that produces an electrical output. An electrical converter is used to convert low-voltage alternating current into high-quality direct current for charging the battery. The rectifier provides a constant voltage across the battery terminal. The other parts of the machine are the mechanical shaft, the stator, two magnetic rotors and the rectifier. The electrical outputs were measured by converters and then fed to the load (12 V DC battery). The current and voltage were recorded with high accuracy at the output of the rectifier, an anemometer was used to measure the wind speed. The accuracy of the measured power was estimated to be 0.5%, while the anemometer accuracy was taken from the product specification (3%).

4.3. Rotational performance of tested blade configurations:

The simplest VAWT design is the Savonius rotor, which acts as a cup anemometer. This design was adopted because it requires relatively low shear wind speeds. Savonius rotors are drag type machines consisting of two or three blades. Savonius rotors with four shapes were tested and their relative rotational performances were analyzed. Experiments were conducted for curved, straight, winged and twisted blade shapes (Shah, 2014, Kumar et al., 2018).

The revolutions per minute (RPM) for each blade type were recorded with respect to wind speed. The straight blade was found to have the lowest RPM in all four shapes, while the best RPM was reported for the twisted blade. In terms of wind speed, the straight blade has lower efficiency compared to the other three blade shapes. This is because the straight blades, separated by 120°, experience a greater drag force compared to the other three configurations. The same wind speed creates less torque for a straight blade shape. The rotational performance for the curved type of vane was closer to the curved type, while the vane has lower revolutions than the curved and curved vanes. Subsequent theoretical and experimental studies were performed only for the curved blade shape configuration.

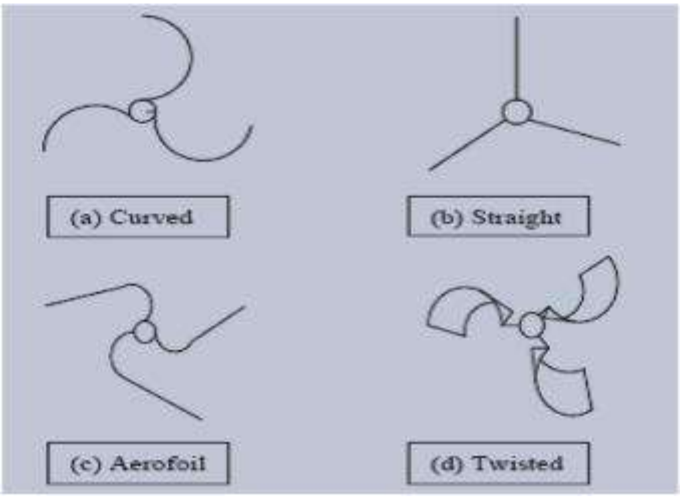

Figure 24: Blades Samples

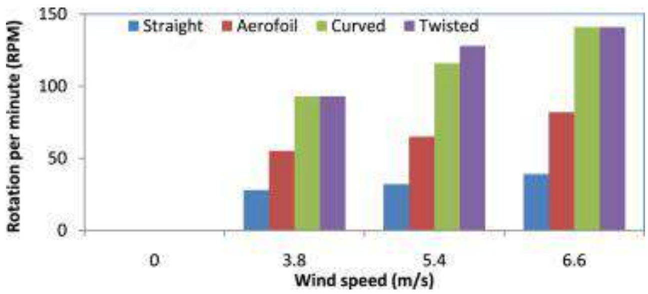

Figure 25: Wind Speed

4.4. Performance results:

A programming script was written in MATLAB/Simulink to numerically analyze the performance of the proposed turbine design. The numerical values were implemented into the model and the outputs were examined. The waveforms of the output voltage and current of the model were analyzed and the simulated values of voltage, current and power were estimated and compared with the experimental results. A calculation was also made for the electrical output and annual energy generated at different predictable wind speeds. Subsequently, the model was used to evaluate the effects of the ratio of wind speed and tip speed on the power and torque coefficients.

Giant. 5, Fig. 6 shows a comparison of model outputs with measured values under the same conditions. The estimated total power generated from the model at a wind speed of 7 m/s came out to be 367.2 W, while the corresponding measured value was recorded as 327.5 W. It is clear that the modeling results are reasonably close to the measured values. Minor differences in these two values can be interpreted as uncontrolled test conditions, wind turbulence, and measurement errors.

The annual energy output of the proposed turbine was estimated (Table 2). The operating range of the turbine was taken from 1 m/s to 17 m/s and the turbine produces its rated power of 9 m/s. At a wind speed lower than 3 m/s (limiting wind speed) there was no power generation from the turbine, on the other hand, the turbine stops generating power at 17 m/s (limiting wind speed). . The annual energy output turned out to be 7838 kWh and the corresponding annual income was estimated to be $846.51 (with a 20-year feed-in tariff of $0.108/kWh). The prevailing market price of these small turbines is between $1,000 and $3,000, depending on several factors. In addition, certain operation and maintenance costs will be incurred. If we were to assume, the total cost of the proposed design is $3000. The simple payback will be 3.5 years and the turbine will generate a net income of $13,967.4 over a 20 year life.

Next, the model was applied to see the effects of TSR on power and torque coefficients (Fig. 7). The power coefficient varies from 0 to 0.46 (and the corresponding torque coefficient varies from 0.001 to 0.06) as the TSR varies from 0.05 to 2.5. As mentioned earlier, the tip speed ratio is the ratio of the tip speed of the turbine to the wind speed, that is, if the tip speed ratio is too low (less than 1.65), more wind passes through the turbine blades without being converted into useful energy, while if the tip speed ratio is too high (more than 1.65), the turbine blades behave like a solid object against the wind and rotor efficiency is reduced due to tip losses and drag.

4.5. VAWT types and selection:

According to Liu et al. the VAWTs are categorized as drag or lift-based devices. The first ones utilize wind drag on the blades to rotate and the last one utilizes the lift on the blades. In figure it can observe these categories.

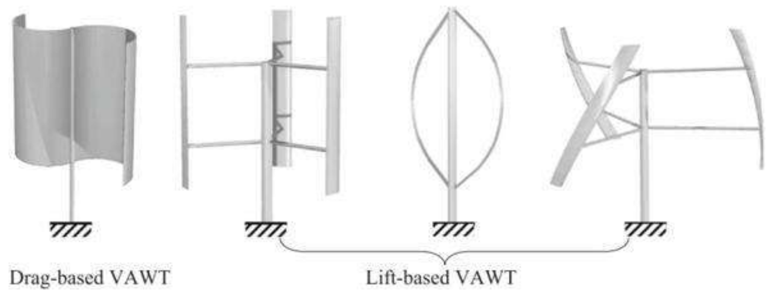

Figure 26: VAWT Types

4.6. Straight type:

These blades usually are used in small-scale, fixed pitch, rooftop designs are commercially available for domestic and other applications. The straight blades have a high value of CpCp (0.23). This configuration can have any number of blades, from one to a configuration of five. However, the most used are two-bladed (commonly called H-type turbines) or three-bladed. In figure it can be the straight blades with two and three blades.

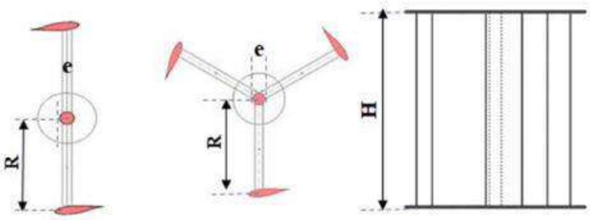

Figure 27: Straight VAWT

4.7. Our Turbine Design:

Figure 28: Design

Figure 29: Design

4.8. Wind velocity self-starting of different types of blades:

DWT type	Number of blades	Wind velocity self-starting (m/s)						
		3	4	4.5	4.85	5.15	6.45	7.65
Straight	2	0.2495	0.2506	0.2635	0.275	0.2895	0.3076	—
	3	0.2407	0.2494	0.2606	0.2678	0.2846	0.3065	—
Twisted 70°	2	0	0	0	0	0.0372	0.0757	0.1216
	3	0	0	0	0.0195	0.0597	0.1008	0.1323
Helical 120°	2	0	0	0	0	0.0449	0.0690	0.0889
	3	0	0	0	0.0427	0.0789	0.1332	0.1465

Figure 30: Wind velocity table

4.9. Block Diagram:

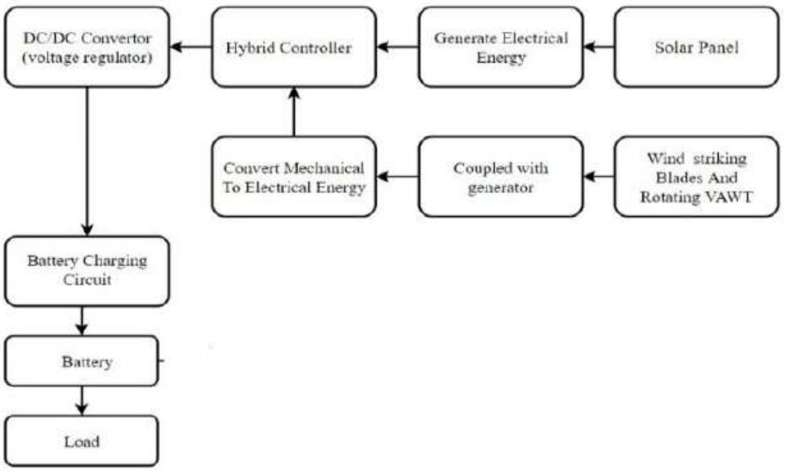

Figure 31: Block Diagram

4.10. Compare with past works on vertical axis wind turbines:

Our project	Previous Work https://www.researchgate.net/publication/359773538_VERTICAL_AXIS_WIND_TURBINE
We use four curved blades. Which are light weight and easy to move.	They used 6 and 8 blades that effect on weight.
Use solar with wind that work with both wind and solar.	They use wind only but if they use solar they are not implement solar on road.
Use relay that switch wind to solar and solar to wind.	They not use auto relay.
Use two bearings that make it frictionless.	They use one bearings and use cycle tyre to fit the blades which weight is high.
Use gear that connect with alternator with belt which increase RPM.	They connect rod directly on alternator.
We use mono crystalline solar panel which is small in size but give high efficiency.	They use poly crystalline which have low efficiency.
We use PVC blades of 1 feet length and use inverter.	They use 2 to 2.5 feet length blades and not use inverter and buck to improve efficiency and use turbine direct.

Figure 32: Before and After Work on Turbine

Chapter 5
Results:

1. Wind Required:

The calculation below will tell us how much wind speed is required to rotate the blades ofwind turbine.

Blade Surface area:

A= Length × Width × Number of BladesA= 2Ft × 0.5 Ft.3

$A = 3Ft^2$

F≈ 0.5 × Air Density × Wind Speed^2 × Blade areaF≈ 0.5 × 1.2kg/m^3 × (3.3m/s)^2 × 0.372m^2

F≈ 0.901N

Torque:

T= Force × radius

T= 0.901N × 0.3048mT= 0.313Nm

How much wind is required to rotate turbine blades?

Wind Speed= $\sqrt{T/(0.5 \times \text{Air density} \times \text{Blades area } \times \text{Radius}}$

Chapter 6

Implication on Society:

1. Sustainable Energy Generation: The integration of solar and wind energy in a hybrid system provides a more consistent and reliable power supply. By harnessing these renewable sources, the project contributes to reducing the dependence on fossil fuels, leading to a greener and more sustainable energy generation.

2. Climate Change Mitigation: As the project relies on clean energy sources, it helps mitigate the effects of climate change by reducing greenhouse gas emissions. This transition to renewable energy contributes to global efforts to limit global warming and its associated impacts on the environment and society.

3. Energy Independence and Security: The adoption of renewable energy technologies enhances energy independence for the region or country. By diversifying the energy mix, societies can reduce vulnerability to price fluctuations in fossil fuels and geopolitical uncertainties related to energy imports.

4. Rural Electrification and Community Empowerment: Implementing renewable hybrid projects in rural areas can extend access to electricity, positively impacting the lives of local communities. Reliable electricity supply enables economic development, improved healthcare, better education, and enhanced overall living conditions, empowering rural populations.

5. Job Creation and Economic Growth: The development, installation, and maintenance of renewable energy systems create job opportunities across various sectors. This job growth can stimulate the local economy and foster a skilled workforce in the renewable energy industry.

6. Technological Advancements: Research and development in renewable energy technologies can lead to innovations and efficiency improvements. This progress not only benefits the specific project but also contributes to advancements in the broader renewable energy sector, driving future sustainable solutions.

7. Reduced Environmental Impact: Unlike conventional power sources, such as coal or natural gas, renewable energy sources do not produce harmful emissions or contribute to air and water pollution. By using solar and wind energy, the project helps preserve biodiversity and protects ecosystems.

8. Resilience to Natural Disasters: Renewable hybrid systems can enhance the resilience of energy infrastructure against natural disasters. Distributed generation allows for localized power supply, reducing the risk of widespread power outages during extreme weather events.

9. Public Awareness and Education: Implementing renewable energy projects can raise awareness among the public about the benefits of clean energy sources and the urgency of transitioning to sustainable practices. Education and engagement initiatives can further promote renewable energy adoption in society.

10. Global Leadership and Cooperation: By investing in renewable energy projects, a country can position itself as a global leader in sustainable development and clean energy initiatives. This can foster international cooperation and partnerships to address climate change on a larger scale.

Project on renewable hybrid for power and harvesting for domestic and commercial application has the potential to bring about positive changes on multiple fronts, including environmental protection, social development, economic growth, and international cooperation in the pursuit of a more sustainable future.

Chapter 7:

Project Sustainability and Lifelong Learning:

1. Project Sustainability:

Project sustainability refers to the ability of your hybrid solar and wind system to maintain its functionality, efficiency, and benefits over an extended period. In the context of your thesis, here are some key points to consider:

a. Environmental Impact: Assess and compare the environmental impact of your hybrid system with conventional energy sources. Focus on reducing greenhouse gas emissions, minimizing resource consumption, and preserving the ecosystem.

b. Renewable Resource Utilization: Highlight how your hybrid system utilizes two renewable energy sources (solar and wind) to maximize energy generation and minimize dependency on non-renewable resources like fossil fuels.

c. Reliability and Durability: Investigate the reliability and durability of the components used in your system. Ensure that the system can withstand various environmental conditions, operate efficiently, and require minimal maintenance.

d. Economic Viability: Analyze the cost-effectiveness of your hybrid system concerning installation, operation, and maintenance. Assess its potential for long-term energy cost savings.

e. Social Acceptance and Benefits: Evaluate how your system can positively impact society by providing clean energy, potential job creation, and improving energy access in remote or underprivileged areas.

2. Lifelong Learning:

Lifelong learning is an essential aspect of any engineering project. It involves continuously acquiring new knowledge, skills, and insights throughout your career. In the context of your thesis, here are some points to consider:

a. Latest Advancements: Research and include the latest developments in solar and wind energy technologies. Keep yourself updated on cutting-edge innovations in the field to ensure your project stays relevant.

b. Continuous Improvement: Discuss how your project can be further improved or optimized in the future. Address potential challenges and propose ideas for enhancing the system's efficiency, performance, and integration with other technologies.

c. Industry Trends: Understand the current trends and market demands related to renewable energy systems. This knowledge will help you identify potential applications or areas where your hybrid system can be utilized effectively.

d. Networking and Collaboration: Engage with professionals, researchers, and organizations working in the renewable energy sector. Networking and collaboration can open doors to new opportunities and ideas for future projects.

e. Documentation and Dissemination: Properly document your project, findings, and conclusions. Consider publishing your work in conferences or journals to contribute to the scientific community and share your knowledge with others.

Remember, sustainability and lifelong learning go hand in hand in engineering. By creating a sustainable project and fostering a mindset of continuous learning.

Conclusions:

Although we were able to improve on the previous work that was handed over our group, there is a never-ending process that constantly improves inventions and new designs. Wind turbines are a start for society to reduce the damage done to the earth by not using energy sources that produce pollution. Hopefully this project could advance research and testing about VAWT systems and provide insight for other groups to complete further testing and improve efficiency and power of vertical axis wind turbines.

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