Savonius Wind Turbine and Solar Panels Road Electric Station

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Abstract This (***Savonius wind turbine and solar panel***) ***the project is all about design and manufacturing a Coaxial wind turbine to convert wind speed into rotational motion by using this turbine and its top solar panel to increase the output power. It can be installed in and around any road, park, or public facility area, preferably between roads or drops. This project presents a review of the performance of Savonius wind turbines. This type of turbine is not commonly used and its applications for obtaining useful energy from air stream is still considered as an alternative source. Low wind speed start-up, working with any wind direction, and less noise are some advantages of the VAWT- Savonius model. This project consists of three phases; designing, fabrication, and evaluating. An actual of gained*** .

1 INTRODUCTION

1.1. Renewable energy

One of the best sources of energy that can apply the concept of sustainability is renewable energy such as the sun, wind. The current demand for renewable energy in Egypt is very high Whereas, planning and economic development, the Egyptian government recently adopted a long-term strategy to diversify the energy mix used, with renewable energy occupying about 42% by the year 2035 through upcoming joint projects with local and international organizations [1].

1.2. PROJECT DEFINITION

This project revolves around designing and manufacturing Savonius wind turbines that can convert Wind using a vertical axis wind turbine (VAWT) to obtain useful energy. And above this turbine, there is a solar panel to use the sun for energy production. The current demand for renewable energy in Egypt is very high Whereas, planning and economic development, the Egyptian government recently adopted a long-term strategy to diversify the energy mix used, with renewable energy occupying about 42% by the year 2035 through upcoming joint projects with local and international organizations [1]. One of the best sources of energy that can apply the concept of sustainability is renewable energy such as sun, wind, and rivers. The positive point of wind energy is that unlike solar energy that is only used with sunlight, the wind turbine can be useful all 24 hours a year.

Another concept of sustainability is the way we should use this renewable energy Energy efficient, and environmentally friendly. This, in turn, will destroy the environmental Risks and improvement of the Egyptian community's health and lifestyle. Roads, parks, schools, and public utilities are major consumers of this energy Consumers should be exposed to wind and sun from time to time. The idea of this project is the transformation This wind and solar energy use Savonius wind turbines and solar panels to get useful power using it as a coil A power

2- LITERATURE REVIEW

2.1 PROJECT BACKGROUND

Energy is the main economic base of any country. Sources of energy are not easy to have. Having multiple sources of energy is extremely important to secure the basic living requirement of any country. Utilizing nature could help in converting some of the natural phenomenons such as sun, wind, sea, and oil into useful energy. This kind of energy is called renewable energy. the definition is that renewable energy is from an energy resource that is replaced rapidly by a natural process such as power generated from the sun or the wind." Recently, the increasing demand for renewable energy is very well noticed. According to a report by the International Energy Agency, the increase in the amount of electricity produced. According to the developments, events, and political developments that Egypt has witnessed during the past years and their impact on the implementation of renewable energy projects in particular [2], and since the strategies are flexible enough to cope with the developments and events, the renewable energy strategy has been modified to target 20% of the total energy produced in 2022 [3]. as shown in figure 1

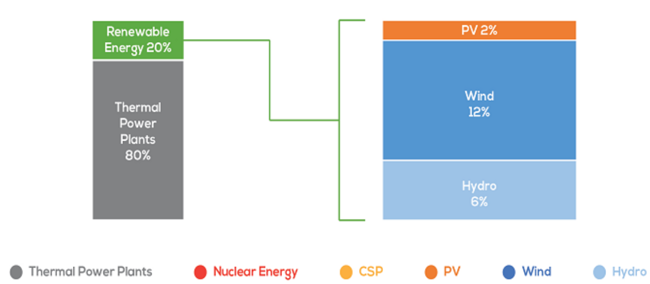

Figure 1 Electricity Production 2022

The traditional power plants in Egypt are mainly working on fuel either gas or oil which are not environmentally friendly.

EcoSpark environmental charity has considered oil power plants as one of the most contributors to environmental pollution. EcoSpark environmental charity has listed the below most significant environmental impacts [4]:

- Oil causes air pollution and greenhouse gas emissions.
- Oil uses large amounts of water and creates water pollution and thermal discharge.
- Oil creates hazardous sludge and solid waste.
- Extracting and refining oil is environmentally destructive.
- Transporting oil is risky and can harm the environment.
- Oil is a non-renewable electricity source.

Such the above environmental effects lead us to think seriously about renewable energy sources, which will eliminate the environmental hazard and improve health and lifestyle. Wind energy is one of the most important sources of energy. Wind energy concept Convert wind kinetic energy into mechanical energy. This energy drives the blades That turn generators that produce electricity. Our project is commensurate with the wind source. The idea of this project is to convert winds using Savonius wind turbines and use solar radiation to produce energy They are two types of wind turbines, Horizontal Axis Wind Turbines (HAWT) as shown in figure 2 is more commonly used across the world and they are used as a power plant [5] [6].

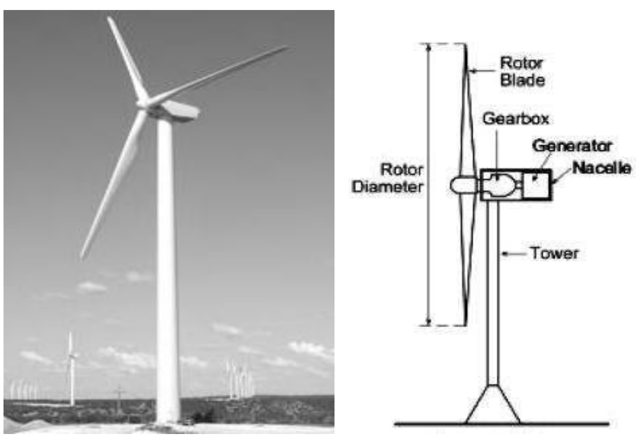

Figure 2 HAWT overview layout (Horizontal Axis)

A type of turbine is more efficient than wind turbines and vertical axis wind turbines, "in research studies evaluating the performance of wind turbines, The horizontal axis machines are proven to be more efficient than the vertical axis machines. However, the horizontal wind turbine blades span greater than the vertical axis machines Which limit the narrow spaces. Some people also find the blade area too large for Horizontal axis machines are rejected.[6]. The other type of wind turbine is the Vertical Axis Wind Turbines (VAWT) as shown in figure 3.

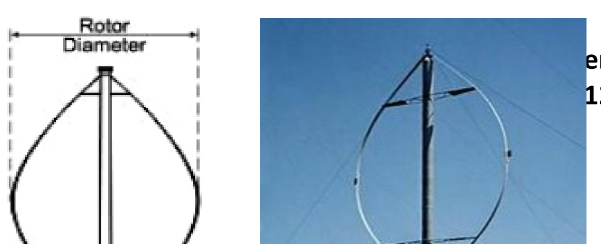

Figure 3 VAWT overview layout (Vertical Axis)

VAWT is the most popular of the turbines that people are using to make their homes a source of renewable energy. VAWT is not as commonly used as the Horizontal Axis Wind Turbine. The reason behind that is that VAWT is less efficient than HAWT when considered as a power plant generator [6]. However, for the small scales like homes, parks, or offices VAWT is more efficient. "Vertical axis turbines are powered by the wind coming from all 360 degrees, and even some turbines are powered when the wind blows from top to bottom. Because of this versatility, vertical axis wind turbines are thought to be ideal for installations where wind conditions are not consistent, or due to public ordinances the turbine cannot be placed high enough to benefit from steady wind [7].". Figure 4 shows the configuration of HAWT vs VAWT.

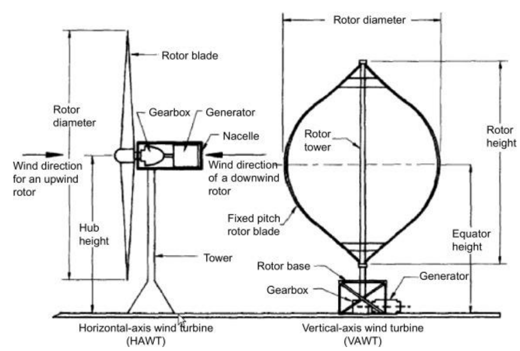

Figure 4 Typical diagram of HAWTs and VAWTs.

2.2 PREVIOUS WORK

There are two different styles of vertical wind turbines. One is the Savonius model, which is our project is based on, and the other type is the Darrieus model. The first model looks like a gallon drum that is been cut in half with the halves placed onto a rotating shaft. The second model is smaller and looks much like an egg beater. Most of the wind turbines being used today are the Savonius models. The Renewable Energy UK website provided some information about these two models. "A Savonius is a type of vertical axis wind turbine (VAWT) generator invented in 1922 by Sigurd Johannes Savonius from Finland though similar wind turbine designs had been attempted in previous centuries [8]." This is how the Savonius turbine is in figure 5 [9] .

Published by the International Research Journal of Engineering and Technology (IRJET) Publication of a paper entitled "Design, Analysis, and Manufacture of Savonius Vertical axis wind turbine "[10]. This research discussion was to showcase the efficiency of the Savonius model in varying wind conditions as compared to the traditional horizontal axis wind turbine. It evaluated some observations that showed that at low angles of attack the lift force also contributes to the overall torque generation. Thus, it can be concluded that the Savonius rotor is not a solely drag-driven machine but a combination of a drag-driven and lift-driven device.

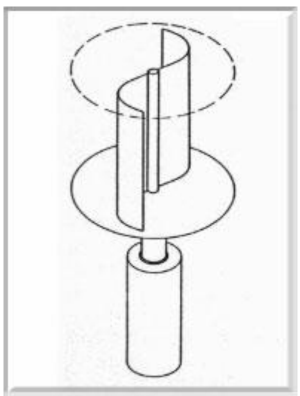

Figure 5 Savonius Wind Turbines

Therefore, it can go beyond the limit of the Maximum power coefficient Cp established for the purely drag-driven machines.

Some of these researched conclusions are that The vertical axis wind turbine is a small power generating unit with the help of a free source of wind energy. It is designed under consideration of household use. Generally, At least 10% power of the consumption can be fulfilled by the Savonius model.

2.3 PROJECT OBJECTIVES

The main objective of this project is to obtain energy from the wind and the sun. Therefore, this project is green

A source of energy and has no impact on Earth's life. These wind turbines are small They can produce up to 500 watts per turbine.

Another goal of this project is to acquire and practice some engineering concepts such as:

- Learn about wind energy and the different ways to convert it into useful energy, or learn about solar energy and convert it.
- Learn the difference between Vertical Axis Wind Turbines (VAWT) & Horizontal Axis Wind Turbines (HAWT)

2.4 PROJECT SPECIFICATIONS

This project is 1.3 meters high and is expected to produce a total capacity of 500 watts.

The turbine material is iron shafts and turbine blades are made Lightweight aluminum alloy or teak iron. The turbine can start with low wind speed

Solar panel (45 * 62cm)

2.5 PRODUCT ARCHITECTURE AND COMPONENTS

The main components of the project are the draft turbine which includes (blades, vertical) with an electric generator connected to the end of each generator shaft. Generators' wires are connected to a normal control element which includes (transformer, controller, and battery are connected to and from the normal position of the popup windows to the charge controller. , which identifies the initial functional diagram that illustrates the projected project horizons. With Polycrystalline Solar Panels 40 Watt 12 Volt (45 * 62 CM) and charge controllers and Battery and LED

1- Project components in detail. https://www.green-mechanic.com/2013/03/vertical-axis-wind-turbine-parts.html, Guidewire, Hub, Rotor, Blades, Shaft, Brake, Gear, Generator, and Base. Solar cell
2- Blades material, The material we want to use:
   1-Aluminum: Lightweight, longer life span
   2-Iron: cheap and heavy, with a small percentage of rust, so it is painted with an insulating paint
3- Types of generators that use.- iskra aag 0403 14v 33a
4- Wind speed in suggested places. speed 16kts 28°49'05", 32°43'42" Zaafarana, Ra's Ghareb Road, Zaafaranah, Red Sea Governorate, Egypt
5- The number of the least problematic baled and the distance between them, And the appropriate thickness for each blade Prices of Battery, generator, solar panel, and wires [11]

Working principle:

The Savonius wind turbine is a simple vertical axis device having a shape of half-cylindrical parts attached to the opposite sides of a vertical shaft (for two-bladed arrangement) and operate on the drag force, so it can’t rotate faster than the wind speed. This means that the tip speed ratio is equal to 1 or smaller. As the wind blows into the structure and comes into contact with the opposite facing surfaces (one convex and other concave), two different forces (drag and lift) are exerted on those two surfaces. The basic principle is based on the difference in the drag force between the convex and the concave parts of the rotor blades when they rotate around a vertical shaft. Thus, the drag force is the main driving force of the savonius rotor. Fig 6. (a) shows characteristic parameters of a savonius wind turbine with two semi-circular profile blades [12]. Butaud and Besnard have highlighted the concept of the drag wind turbine for the Savonius turbine. The dynamic analysis of its operation shows the influence of lift force. The Savonius can’t be classified into one or the other of these categories. Its efficiency at the start is mainly due to drag force, but its maintenance in the rotation is mainly due to the force of lift[13].

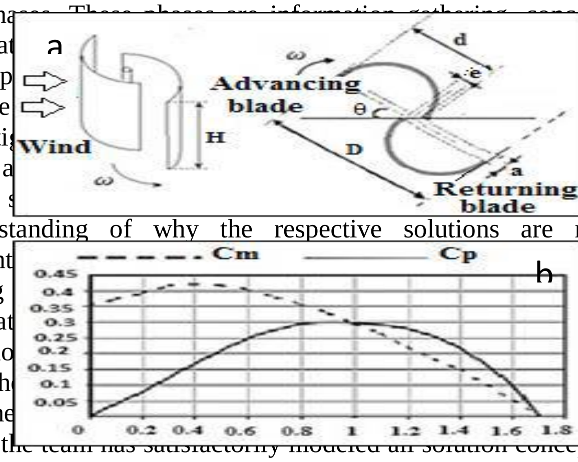

Figure 6 (a) two-bladed Savonius rotor, (b) Conventional Savonius rotor performanc

2.6 APPLICATION

This project idea is very simple, as it focuses on harnessing wind energy through design And VAWT manufacture consciousness solar panel. This could be a project Installed across public utilities and roads. Facilities like public parks, on top of the stadiums Where the winds are very strong, around stadiums, service buildings, and on roads Streets. It can also be installed in taller buildings.

SYSTEM DESIGN

REQUIREMENTS, CONSTRAINTS, AND SPECIFICATION

3.1General specifications

Savonius wind turbine is a new method of vertical axis energy production. This is new The power source is useful in modern cities because of its beautiful design and free from noise. These Wind power generators. The Savonius is compact and fitted with a solar panel that can output up to 500 watts.

The positive point of wind energy is that, unlike solar energy that only can be used with sunlight only. Wind energy can be useful all 24 hours a year. This project is a green source of energy and does not affect the life of the earth. There are no effects on the environment at all. Moreover, it reduces the CO_2 and CO gases that affect the environment in the earth. One of the biggest challenges is the social acceptance of Savonius Wind turbines[14].

3.2 Constraints and requirements

One of the most difficult problems is the lack of necessary equipment needed for the analysis and selection of materials accurately in the university. Also, in the market, it was really difficult to find some of the needed materials. These problems make the function of this project relying upon some parts of the design. Besides the Lack of important resources, the lack of financial support was a major obstacle in our way even though the budget was estimated

3.3DESIGN METHODOLOGY

The methodology applied to this project can be divided into six ph... pt generat... nt, concep... Before ... gh investi... ns have a... ce these ... an understanding of why the respective solutions are not current... is taking ... nd evaluat... n). Solutio... els are th... on parame...). Once t... pts of interest, the concept that performs best analytically, in addition to meeting all criteria and constraints, is selected (concept selection). The analytical model may then be verified experimentally, using a small-scale modeling scheme or through a full-scale experimental model. The objective of this project is to design a vertical axis wind turbine (VAWT) that could generate power under relatively low wind velocities. To accomplish this goal, the objectives are to:

- Analyze how different geometry of the wind turbines would affect the output power of the wind turbine.
- Vibrations analysis by testing how the vibrations caused from the rotations of the wind turbines affect the structural integrity of various aspects of buildings' structures.
- Compare the operation of turbines concerning the numbers of attached blades. To meet the above objectives, the tasks were to:
- Conduct background research and analysis on wind turbine technology.
- Design initially turbine blade for testing.
- Looking for a power generator that has good efficiency with low startup speed.
- Create an experimental setup.
- Manufacture parts and build model
- Develop future design recommendations.

Project plane :

After we divided into groups and the project were chosen .and Team leader also nominated and assigned by the group members. we started a timeline that the team developed- Using the timeline we succeeded in continuing with the project steps which are:

1- Planning:

- The roles were divided for each person what he was looking for, his method of operation, his faults, method of manufacture and installation, and he informs us of what he reached

2- Research and Analysis.

- Research about:

1- Project components in detail.
2- Blades material.
3- Types of generators that use.
4- Wind speed in suggested places.
5- The number of the least problematic baled and the distance between them, And the appropriate thickness for each blade
6- Prices of Battery, generator, solar panel and wires

Design & Manufacturing.

By doing some researches, we find an article that focuses on the turbine blade angle. A research article published by Advances in Mechanical Engineering (AIME) with the title of EFFECT OF THE BLADE ARC ANGLE ON THE PERFORMANCE OF A SEVONIUS WIND TURBINE [15]. How to improve turbine efficiency by choosing the best blade angle, Effect of blade arc angle on the performance of typical two-blade Savonius winds. The turbine is checked using the transient computational fluid dynamics method. Simulation-based on Reynolds' Avergide Navier - Stokes equations, and re-normalization The turbulent group model was used.

Simulations

were based on the Reynolds Averaged Navier–Stokes equations, and the renormalization group $\mathcal{K}\_\varepsilon$ turbulent model was utilized. The numerical method was validated with existing experimental data. The results of this article indicate that the turbine with a blade arc angle of 160° generates the maximum power coefficient cp 0.2836, which is the highest that gain from the experiment. The article provided below the table, which shows the maximum coefficient of power for different cases. The figure shows the blade dynamic torque coefficient for different blade arc angles Table The maximum coefficient of power for different cases [15]

Case	Blade angle	CP max	CP gain percentage
1	150	0.2687	2.67%
2	160	0.2836	8.37%
3	170	0.2835	8.33%
4	180	0.2617	0.00%
5	190	0.2521	23.67%
6	200	0.2271	213.22%

The performance of the Savonius wind turbine can be expressed in the form of the coefficient of power Cp Eq.(4) and torque coefficient Cm Eq.(5) in comparison with the tip speed ratio (TSR) λ Eq.(1). TSR is a ratio between the speed of the tip blade and wind speed through the blade obtained by Eq.(1).

$$\square = \frac{V\,rotor}{V} = \frac{\omega R}{v} \qquad (1)$$

$$P_A = \text{Kinetic energy} \times \text{mass flow rate} = \frac{1}{2}V^2 \times \rho S V \qquad (2)$$

$$P_T = T\omega(watt) \qquad (3)$$

$$C_p = \frac{P_T}{P_A} = \frac{P_T}{\frac{1}{2}\rho S V^3} \qquad (4)$$

$$C_m = \frac{T}{T_W} = \frac{4T}{\rho S V^2} \qquad (5)$$

A conventional Savonius rotor is a rotor with the geometrical parameters a and e are respectively equal to 0 and D/6.This rotor has been largely studied. The values of Cp and Cm are experimentally determined as a function of the velocity coefficient λ, (b).

Parameters that affect the performance of the Savonius wind turbine

Effect of blades number conclude that the optimum number of blades is two for the Savonius rotor whether it is single, two, or three-stage, also conclude that the two blades Savonius wind turbine is more efficient, it has higher power coefficient under the same test condition than that of three blades Savonius wind turbine. (a) in figure 7

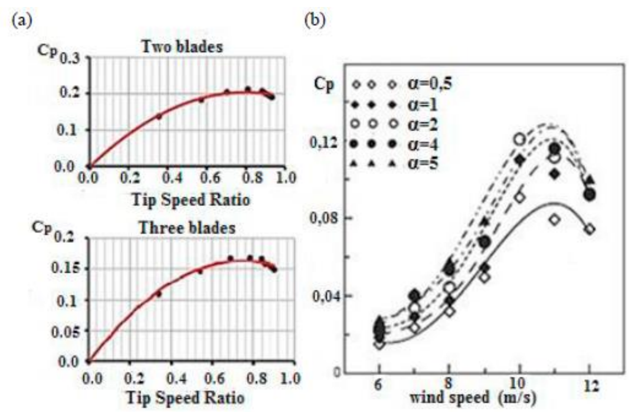

Figure 3 a) The Cp variation with the TSR for two & three blades.[11], (b) Variation of Cp with wind speed for different aspect ratios

3.0 Turbine design & sketch

After gathering the basic research, we began planning the project. We arrived at A point where we start the initial sketches of the design. We've drawn the gross overview of the project, which is a turbine, generator, and light, as shown in the figures

Undertake the proposed research investigation following the agreed specification and procedures

Specification of the project :

the diameter of the blade .D	30mm
higher of blade H	1M
the thickness of blade t	0.8mm

The density of iron or Aluminium (material of blade)	Iron :7.874 g/cm³ - AL:2.7 g/cm³
Solar cell	40watt - 12volt -
Number of blades	2blade

rotor rule: high static and dynamic moment, robustness, low noise, and low cost. agreed procedure. Match resources efficiently to the research question or hypothesis. The team went to Bab al-Luq Street in the center of the country and inquired about its Components such as the energy-saving headlamp, 127 dynamo cars; The Battery and charging regulator in some stores such as Ram, Abdul Shafi, Al- Al-Nakhili and many others, and we asked them about solar cells in Al-Mamun Another shop and a group of Zahbet from Al Ghafali, Shalaby Street, Al Matariyah We asked about the Iskra Aag 0403 14v 33a Demo, which is a dunam Available in the market. And a group of the team went to the blacksmith shop Ask about the types of iron and aluminum sheets and compare them, or make sure that there are specifications that are satisfied in the project.

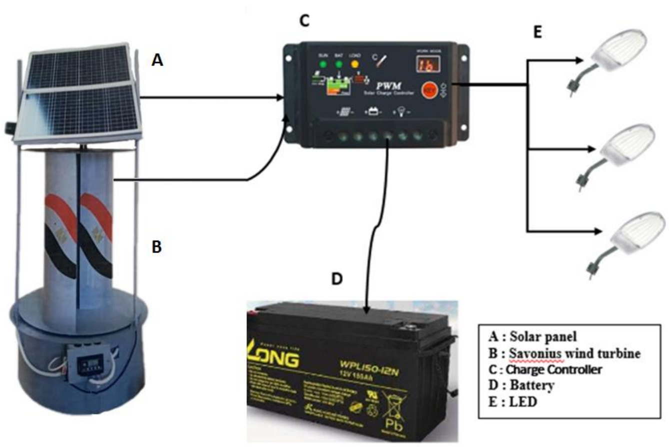

Figure 8 delivery form

RISK / LIKELIHOOD ASSESSMENT
The probability of an accident when The transportation of wind turbine components is dependent on Many factors, such as the number of vehicles on the road, and The condition of the road, whether the road has many turns and Curves, and speed limits for the road [17]
Risk Evaluation / Likelihood
The likelihood of slipping, tripping, and falling should not be so high if the proper safety measures and regulations are diligently considered. This includes utilization of the correct resources, workers are trained, fit, and put on their Protective Equipment (PPE) [18]
Risk Analysis
A load of accrete ice can reach up to 50% of the weight of a blade structural weight which poses a serious risk to the structural integrity of the wind turbine and the surroundings. Ice accretion and irregular shedding on blades can lead to load imbalance, increased fatigue loads, wind turbine vibrations Moreover, there is a possible danger that accumulated ice is thrown away while melting from the blades during rotation due to centrifugal force [19]
Although a turbine can operate in gusty winds, this is not always the case; Low torque and dynamic stability issues can restrict functionality in conditions for which the turbine was not specifically designed. -Vibration can sometimes be a problem and even increase the noise generated by the turbine. Airflow at ground level can increase turbulence and, in turn, increase vibration. This can wear out the bearing. Sometimes, this can lead to more maintenance and therefore more costs associated with it. In earlier models, the blades were prone to bending and cracking, causing the turbine to malfunction. Small units on top of buildings or other structures can be subject to impact forces, adding lateral stress necessitating ongoing maintenance and the use of stronger, more durable materials.

2.3 FACTORS THAT CONTRIBUTE TO CHOOSING A PROJECT PROCESS

The main thing is that the project is renewable energy and this must be provided in the future. A large number of places can choose the project through public facilities and ways to produce energy. Operating the device regardless of the direction of the wind The turbine is cost-effective and the process is very simplified even it is suitable for a minimum It is an application that has little electrical loads, it also provides minimal noise integration and is very simple maintenance, most importantly, it must be provided in the future, the hair adjacent to the axis and start to work very suitably makes it long-lasting. [20] [21]
Savonius wind turbines, which are often placed at ground level and environments, face more turbulence and vibration issues that damage the turbine and prevent its power output when operating.
The uncontrolled diameter and the non-approved supply ratio to the project Impact of rotor height, un-adjusting, and torsion angle. The torque factor increased with the increase in the peripheral velocity ratio. With more loads applied, turbine rotation is prevented and consequently, the output torque is increased.
A tropical storm is strong while rotating, facing the primary blade from the vertical axis rotors with increased drag - or aerodynamic resistance - on the blade facing a tropical storm that may cause significant particle damage from the blade and thus prevent the turbine from producing any energy. Increase shaft diameter And increase the length of the blade tendon Increasing pressure coefficient, dimensions [9] [22] [23]

CONCLUSION

From our research, we were able to come up with many important conclusions and suggestions which will profit the future advancement of individual vertical pivot wind turbines. We could outline a VAWT framework that enhanced power yield when contrasted with the past projects. From our results, we were able to recommend new design aspects to improve the system and efficiency. Inefficient wind speed was the huge impact getting the required power output, the minimum speed is required to have acceptable output power taking into consideration efficiency between theoretical and experimental results. Even though we were able to make this design of Vertical Axis Wind Turbine but there is a never-ending process to always improve upon inventions and new designs. Wind turbines are a start for society to lessen the damage done to the earth by not using energy sources that produce pollution. Hopefully, the project could propel research and testing on VAWT frameworks and give knowledge for different gatherings to finish additionally testing and enhance productivity and execution of vertical pivot wind turbines.

Using the data we received, we made recommendations for future studies on the potential rade wind turbines. We hope these recommendations help you Developing a technology that will allow green energy to reduce energy costs in the Average family and environmental improvement. Future tests can help determine the feasibility Of homes, neighborhoods, or cities that operate with wind turbines and the ability to run Renewable energy. Turbine performance testing and research results in this project demonstrated this The Savonius split is the best plan tried so far in WPI. the reason is The wide surface range of the divided Savonius enabling him to capture as much as possible Loads of wind. We are confident that further research must be completed with various Savonius Plan in light of this reality. The outlines of the Savonius turbine are basic, unpretentious to manufacture, and Besides, it is incredibly not affected by turbulence in the wind. Another suggestion to improve Savonius' design in our opinion is to create more Aerodynamic support to the cusp of Savonius. This design will reduce the energy it needs to Spin with the wind. This would allow Savonius to spin in the wind more efficiently Increase the revolution rate. While we don't expect this to make much difference, Our testing shows that even slight variations in wind speed lead to a large extent of Improve energy output. For the best energy gain in the green energy concept, we highly recommend having it Some solar panels are connected. These panels will add more strength and are easy to use Install and connect electrical components that have already been added to the system.

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Nomenclature

ρ	density of air (= 1.225 kg/m3).
S	swept area of blades (m^2).
V	wind speed (m/s).
PT	maximum power obtained from the wind (watt)
PA	total power available from the wind (watt)
Cp	coefficient of power
ω	angular velocity of the rotor (1/s)
E	overlap ratio e/D
T	actual torque developed by the rotor (N.m)
Tw	theoretical torque available in the wind (N.m)
H	rotor height (m)
AR	aspect ratio H/D
Cm	torque coefficient
R	radius of rotor (m)
λ	tip speed ratio
D	rotor diameter (m)
Θ	rotor blade angle(degree)