The Implementation Of A Magnetic Propelling Phenomenon In A Traditional Vertical Axis Wind Turbine System To Enhance Its Performance Even In Lower Wind Speed Condition

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Abstract

It is essential for human civilization to develop sustainable, inexpensive, and environmentally friendly alternative sources of energy since modern civilizations depend on cheap, abundant energy to thrive. Wind power may offer an effective answer to the world's energy problems. It is a perfectly safe, reasonably priced, and ecologically responsible source of clean and green energy. The air may appear inconsequential to anybody or everyone given the existing situation. We all know that the globe has an uneven surface due to its form, which means that sunrays may impact the surface at various points along the uneven surface with varying intensities. As a result, there is an accompanying degree of uneven heating of the earth's surface, which changes some of the air pressure there. It then results in wind. These air molecules' kinetic energy is nothing more than wind energy. A wind turbine is a mechanical device that converts kinetic energy from the air surrounding it into the necessary kind of mechanical energy. In this study, we concentrated on the repelling characteristics of items that are persistently magnetized and have identical poles. Here, magnetic propulsion's inherent properties are employed as energy sources. Because of the addition of such elements as magnetic repulsion, our VAWT system will function better under conditions with lower wind speeds as well. When wind energy is used as an additional source of energy in a VAWT, the magnets will provide a repulsive force that will contribute various types of kinetic energies to the wind turbines as they transform wind energy's kinetic energy into the necessary mechanical power.

Keywords: Hybrid energy, vertical axis wind turbines, renewable energy sources, and magnets

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I.INTRODUCTION

At the beginning of the 1980s, the energy sector saw a tremendous expansion, which was especially apparent in the wind energy sector. As a consequence, in addition to hydro power, alternative energy, and wind energy, they will also play a large role in the current property energy sector, inside a property energy bank, under the phrase "hybrid energy source." The mechanical system converts the mechanical energy of the wind into the appropriate kind of energy. Now, you may use this mechanical power to move or run a different system, or you can utilize it to turn the generator shaft and generate electricity. A windmill's mechanism experiences a change in air pressure, which causes the blades to accelerate. The spinning blades' holding shaft will start to revolve cylindrically.

The mechanical energy that was before used to directly power other machines from the shaft was now converted into electrical energy by the use of a generator attached to the shaft. As seen in figure 1, there are primarily two kinds of wind turbines: the majority of these feature a horizontal shaft and linked blades. The most common turbine arrangement is the HAWT. The turbine parts, including the propellers, are raised above the ground by a sizable pedestal. Whether or if someone alters the landscape is up to them. However, there is no doubting that placing their systems at a height is a disadvantage when assistance is needed. Additionally, they need a mechanical yaw mechanism that is mounted with the horizontal axis perpendicular to the wind and facing it. Greater power is needed for bigger diameters because the swept area (or rotor diameter) and potential power output are related. The size is constrained by the strength of the blades due to the significant thrust and torque forces they must withstand. Another type of equipment is the vertical axis machine, which is shaped like an eggbeater and features a succession of long, curved blades on a vertical shaft.

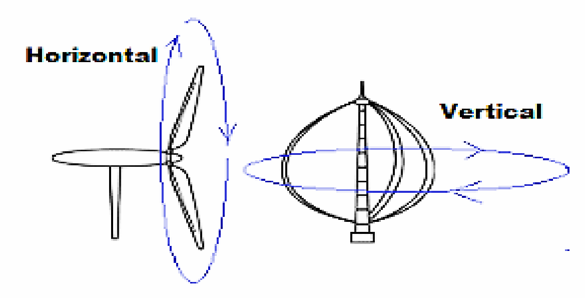

Figure 1: Shaft and Rotor Alternate Configuration

These wind turbines do not require special placement in order to face the wind because they are omnidirectional. Vertical axis designs were taken into consideration in the early phases of development because of the anticipated benefits of omni-directionality. This broad categorization of wind turbines is shown in Figure 2. Because the vertical plane of rotation for vertical-axis wind turbines (VAWTs) is vertical, the primary rotor shaft is positioned vertically. A more ancient and less well-known type of wind turbine is the vertical-axis model. They are straight blades. A vertical-axis wind turbine is a particular kind of vertical-axis wind turbine that has a number of potential advantages over the ordinary horizontal-axis turbines that are now most often used. VAWTs may be pointed in the direction of the wind since they don't need a yaw control system. These are especially helpful in places with unpredictable wind patterns or considerable obstructions, such sizable houses, trees, or other buildings. In addition, VAWTs may be placed close to the ground without a tower construction, making it simpler to access electrical components. In order to make it simpler to maintain the moving parts, a generator can also be mounted near to the ground. And, unlike HAWT, starts rotating when the wind speed is lower.

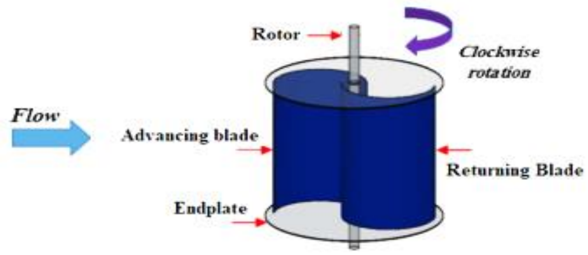

Figure 2: Savonius Type VAWT Systems Configuration.

The development of a VAWT driven by a permanent magnet is the current focus of our study. Due to hybrid energy technology using permanent magnets, this system can function in a variety of wind-speed environment conditions. In this research, we compare the performance of the existing VAWT system to the PM-designed vertical axis wind turbines, which will ultimately replace it.

II. EXPERIMENTAL METHODOLOGY

A. WIND SAIL DESIGN

In this situation, the wind turbines are mechanical structures comprising a shaft, blade, and supporting elements. When the give system is set up and placed in a location with moving air, the air may come into contact with the revolving blades and alter the pressure. The rotor therefore begins to turn in the direction of the carry. Here, mechanical energy from the wind is converted into the needed form of energy and sent down the shaft to a generator or alternative system after the rotor components of the provided system begin to spin. The horizontal axis and the vertical axis are the two main sub-systems in the family of wind turbines. We both agreed to employ a vertical axis wind turbine system with magnetic propulsion in our inquiry. The rotating shaft and plane are vertical in a VAWT design. The rotating shaft itself then has a cylinder-like appearance. The VAWT Systems are the earliest and least well-liked turbines in the series. A number of additional benefits of this design above the more widely used horizontal-axis turbine arrangement. There are essentially two subtypes in the VAWT's structure, which are as follows:

- Darrieus Model.
- Savonius Model.

The Savonius-based turbine system of the VAWT system family uses a drag-type VAWT construction that works like a pedal boat on water. S.J. Savonius is the creator of this technique. The drag-based Savonius Structure is seen in figure 3. It was created over time by using a bucket, plate, or cup as a propelling mechanism.

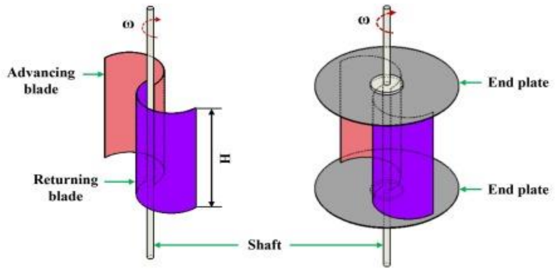

Figure 3: VAWT Model S-Shaped Savonius Type

In this article, the rotary blades of the S-model are referred to as Savonius type rotors. In contrast to lift-based systems, these pull-type VAWT systems provide a particularly strong starting torque and self-starting characteristics. We ultimately chose to base our foundation on the Savonius design with a few minor tweaks after looking at the two main sub kinds of VAWT system rotor components. The main departure from the fundamental Savonius subsystem concept is the inclusion of magnetic repulsion characteristics between the moving and stationary parts of turbines. As a result of this repulsion, the upper half of the turbine's blades will develop scoops; it is required to eliminate these scoops from the turbine and provide a smoother torque as the rotor revolves [4].

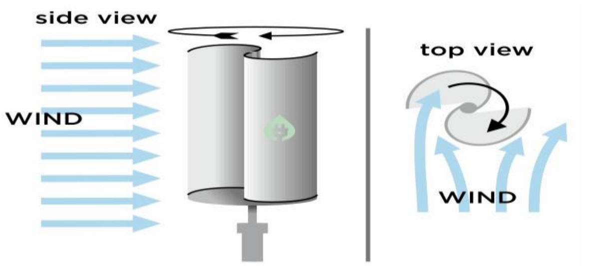

Figure 4: Scoop is created on upper half of the Savonius Model

In contrast to our regular Savonius turbine model [2], we slightly adjusted our design by changing the bending curve of the rotor blades from top to base. A series of triangular faces cut from an aluminium sheet element are swirled from the top to the bottom of the rotor blade in line with our design requirements to accomplish this. Figures 5 illustrate the completed modified Savonius design.

Figure 5: A prototype of modified turbine model

B. PERMANENT MAGNET SELECTION AND ITS CHARACTERISTICS

A magnetic field or force field that is emitted by a magnet may either attract or repel particular materials, such as iron or nickel. Since not all magnets naturally contain the same elements, they can be divided into several categories according to their chemical make-up and magnetism-inducing processes. After being magnetized, permanent magnets continue to have a magnetic attraction.

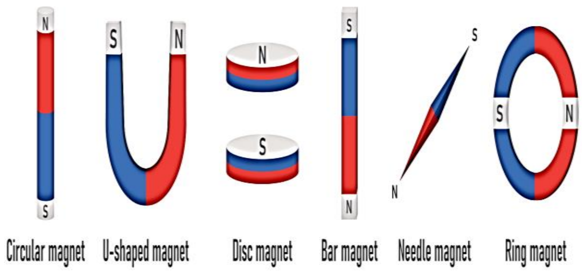

Figure 6: Types of magnets based on shape

Temporary magnets are materials that behave like permanent magnets when a magnetic field is present, but lose their magnetic properties when the magnetic field is no longer present. Samarium cobalt (Sm-Co), Alnico, Ceramic/ Ferrite, and Neodymium Iron Boron are the four main types of permanent magnets (Nd-Fe-B). Permanent magnets are devices that store energy and never lose their magnetic qualities of attraction and repulsion, unless they are physically damaged by heating or hammering. Ceramic/ferrite permanent magnets may be produced rapidly and affordably by pressing sintered iron oxide with barium or strontium carbonate. However, these magnets need to be polished using a diamond wheel because of how frequently they are fragile. They are among the magnets that are used the most frequently; they have a powerful magnetic field and demagnetizing them is difficult.

A magnetic alloy consisting of rare earth elements called neodymium iron boron (Nd-Fe-B) has a strong coercive force. They may be produced often in tiny, compact amounts thanks to the high product energy level. The mechanical strength, brittleness, and corrosion resistance of Nd-Fe-B magnets are weak; nevertheless, if left untreated, these flaws will manifest. They may be utilised in several applications if they are nickel, iron, or gold plated. They are very powerful magnets that are challenging to demagnetize. Time, temperatures, reluctance changes, unfavorable stress, fields, shock, radiation, and vibration are a few of the factors that could have an impact on a magnet's stability.

The B-H curve, sometimes referred to as the hysteresis loop, of each magnet material serves as the foundation for magnet design. This graph illustrates the cycle of a magnet in closed circuit as it is subjected to an external magnetic field, brought to saturation, demagnetized, saturated in the other direction, and ultimately demagnetized once again. The second quadrant of the B-H curve, sometimes known as the "Demagnetization Curve," exemplifies how permanent magnets are used in everyday life. If the air-size gap is maintained and all external fields are kept constant, a permanent magnet will have a single, static operating point. The working point will diverge from the demagnetization curve if this behavior is not taken into consideration while designing the device.

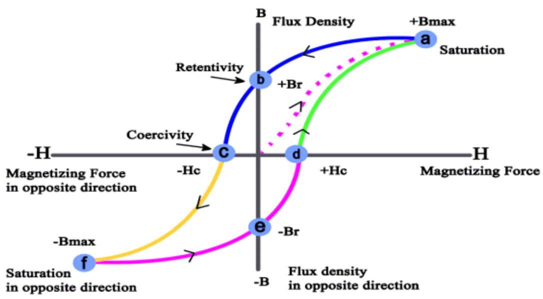

Figure 7: BH-Curve

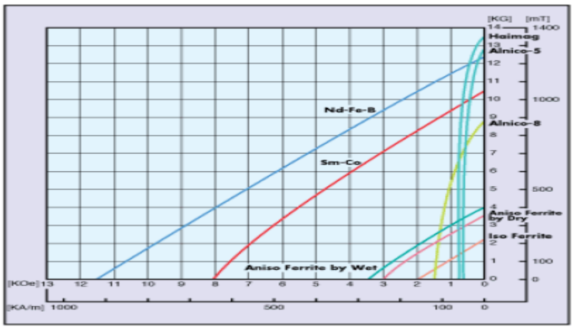

Figure 8: Commercial Magnet BH Curve.

Table 1: Magnetic Flux Density chart

Material	BH_{max}	Tcoef of Br	T_{curie}	T_{max}
Ceramic	3.5	-0.20	460	300
Alnico	5.5	-0.02	860	540
Sm-Co	26	-0.04	750	300
Nd-Fe-B	40	-0.12	310	150

The maximum of the B-H curve's product and its intersection with the B and H axes (at Br for residual induction and Hc for coercive force, respectively) are its three most significant features (BHmax - the maximum energy product). The letter Br stands for the maximum flux that a magnet may generate in a closed circuit. Permanent magnets can only get close to this in practice. The intrinsic curve and the normal curve can be inferred from one another. The normal curve is adequate for design when a magnet is operated statically and without the help of any external fields. The normal and intrinsic curves are used to assess how the material's intrinsic qualities vary in the presence of external fields.

According to the BH Curve of Magnet Materials, the Nd-Fe-B has a very appealing magnetic characteristic, offering better features such as a high magnetic field flux density, provides high magnetic field strength in given conditions, and also has the ability to resist demagnetization in extreme conditions. It was chosen to use a Nd-Fe-B (Neodymium Iron Boron) magnet as a result. Other magnetic qualities, such as the attraction of magnets with like polarities, can be used as a secondary energy source. Permanent magnets can be used to absorb kinetic energy from magnetic propelling events [7].

Depending on how they were created, Nd-Fe-B magnets can be classed as sintered or bonded

[8]. They have replaced other types of magnets in many applications in contemporary goods that call for powerful permanent magnets, such as hard disc drives, magnetic fasteners, and electric motors in cordless tools.

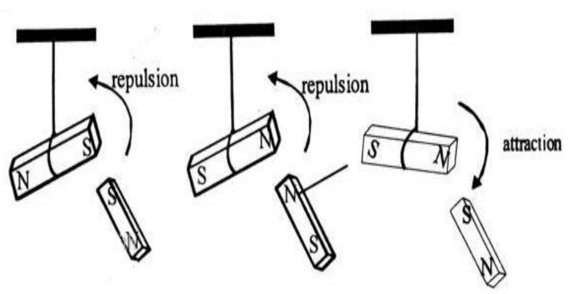

Figure 9: Magnetic Attraction - Repulsion Characteristic

Neodymium-Iron-Born (Nd-Fe-B) permanent magnets were employed in this experiment to create magnetic repulsion. The magnets were placed so that the polarities of similar magnets faced one another. Converting the mechanical energy of the wind and the mechanical energy created by the magnetic attraction into the essential kind of mechanical power.

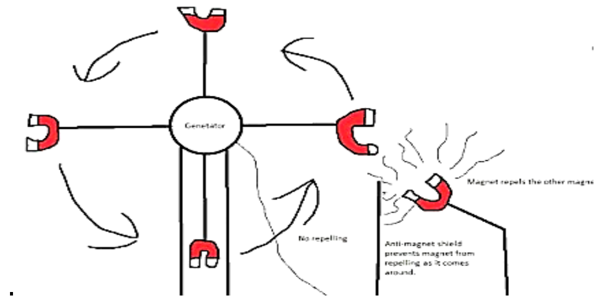

Figure 10: While converting wind energy into mechanical energy, the Magnetic Repulsion can move in a linear or circular fashion.

This study's attempt to increase rotational structure efficacy by incorporating additional kinetic energy without sacrificing the magnets' repelling qualities was successful [8]. By compressing this repellent feature between the mounts and rotary planes, magnetic repulsion may also be easily detected. In contrast, VAWT transforms wind energy into the necessary, reasonable mechanical power, and the force generated by the permanent magnet can also provide a small amount of tolerable kinetic power.

C. VALIDATION PART OF PM-VAWT

Simulink is a stand-alone programme that enhances model-based design and multi-domain graphical simulation for dynamic and embedded systems. A programme named MATLAB and supplemental features like Simulation and Linking were created by the Math work Team. A graphical computer software may be used by users of this application to model, simulate, and analyse a system in a very dynamic environment. The user may design a multi-domain dynamic system by choosing an option from the drop-down menu, which is then planned and evaluated on graphs using the array and matrix operations of a modified library block. We typically use the MATLAB App models for this reason [5].

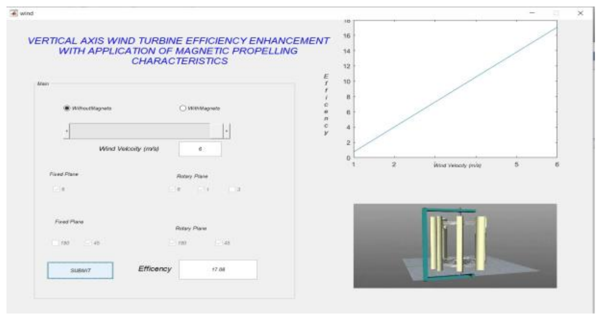

Figure 11: MATLAB for Validation work

In this case, the sweptwing front cross section area, which is perpendicular to air density, air flow, and wind speed, can all be proportional to the total power of wind flow [8]. Additionally, you may write as follows:

$P_W = x = \frac{1}{2}\rho AV^3$

P_W=Total Power in Wind (W/m^2)

A =Rotary Turbine sweptwing area perpendicular to the air flow (m^2) =0.173m2.

ρ= Density of air for given condition (kg/ m^3)

V= Wind Speed Condition (m/sec)

Table2: Power available in Wind at Various Wind Speed Conditions is calculated theoretically

Sl. N	V= Avg. Wind Speed in m/sec	$P_W = x = \frac{1}{2}\rho AV^3$ W/m^2
1.	6.0	22.54
2.	4.50	9. 52
3.	3.20	3. 4
4.	2.80	2. 28

Mechanical Power (P_T) is obtained from the rotary turbine system, is nothing but the operate of the tangentials forces (F) & rotary turbine movement speeds in rotation per minute (RPM) provide by N_r of the rotary shaft.

$$P_T = \frac{1}{60} 2\pi N_r F$$

Force (F) = Angular Acceleration X rotary Turbine Mass.
N_r = Revolution/minutes of The Rotary Turbine
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N_r = Revolution/minutes of The Rotary Turbine

Angular Acceleration = (acceleration / radius of the turbine) revolution /m^2
Total mass of the Turbine = 3.12 kg
Mechanical output powers P_T is divided by the highest volume of total kinetic energy felt by the area of a particular wind turbine can be represented as power coefficient C_P,
$C_P = \frac{PT}{PW}$

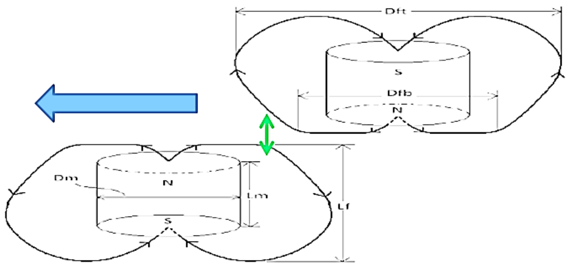


Figure 12: There were two magnets parallel to one another.

Figure 12, illustrates what happened when magnets were arranged on both the rotary and fixed planes at a 180-degree or parallel angle to one another. This caused a little obstruction to the turbine's rotation. When comparable polarity magnets are positioned parallel to one another, the permanent magnet's magnetic field will resist them, making it difficult for the turbine to spin.
It was difficult to lessen the magnetic repulsion that increases resistance when revolving rotary plane magnets come into contact with stationary plane magnets. Permanent magnets' magnetic attraction to one another gives kinetic energy to the turbine while converting the kinetic energy in the wind into mechanical energy.

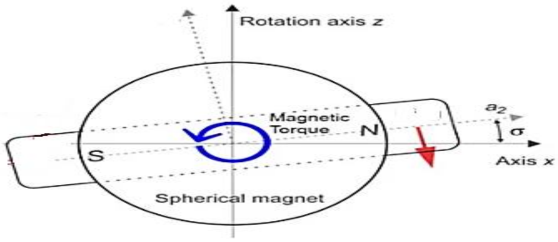


Figure 13: Magnets orientation Visualization Top view.

The resistive repulsive force was reduced by turning the magnets' installation orientation to a 45-degree angle, as shown in Figures 15 and 16. Therefore, the repelling force created when magnets parted ways with the magnetic field was greater than the resistive force created when they coincided. Wind kinetic energy is transformed into the essential kind of mechanical energy as a result of the addition of these repulsive forces. The tests' main objective was to establish the ideal placement and orientation for magnet sets in various wind-speed scenarios.

Figure 14: PM-VAWT Model vs. Conventional VAWT Model

Table 3: Through experiments, the best orientation and location for installing a magnet in a PM-Propelled VAWT at various win speed conditions in order to gain more kinetic energy and smother operation were identified.

S. No	Orientation of Magnets Placement	Wind Speed in m/s	$C_P = P_T/P_W$
1.	Standard Turbine Without Magnets	6	17.08
2.		4.5	14.40
3.		3.2	10.84
4.		2.8	7.64
Permanent Magnet Propelled VAWT Magnet Orientation			
1.	Six magnets were arranged either parallel to one another or 180 degrees apart.	6	18.88
2.		4.5	17.11
3.		3.2	10.54
4.		2.8	6.85
5.	One permanent magnet is positioned 180 degrees on the spinning section, and six permanent magnets are put into the stationary component.	6	17.28
6.		4.5	14.78
7.		3.2	10.69
8.		2.8	7.42
9.	3 magnets were placed in the rotating component with a 180° orientation, and 6 PM were put on the stationary part.	6	18.91
10.		4.5	14.40
11.		3.2	5.27
12.		2.8	4.83
13.	One magnet was positioned in the revolving section at a 45° angle, and six magnets were installed on the stationary component with a 180° orientation.	6	17.47
14.		4.5	15.54
15.		3.2	10.69
16.		2.8	7.30
17.	The six permanent magnets of the stationary section and the three permanent magnets of the rotating part were angled at 45°.	6	17.67
18.		4.5	16.89
19.		3.2	10.99
20.		2.8	7.87
21.	Three permanent magnets and six permanent magnets were arranged at a 45-degree angle in the rotating component.	6	19.32
22.		4.5	18.41
23.		3.2	16.49
24.		2.8	14.38
25.	The angles of the six magnet sets were 45 degrees in both the plane	6	24.46
26.		4.5	22.20
27.		3.2	17.61
28.		2.8	15.96

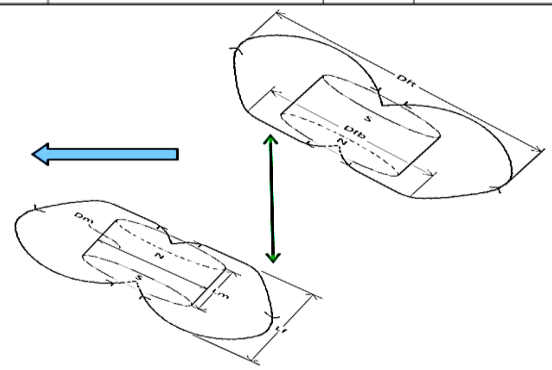


Figure 15: The turbine will encounter less of the resistive force produced by magnetic repulsion while entering in to magnetic field

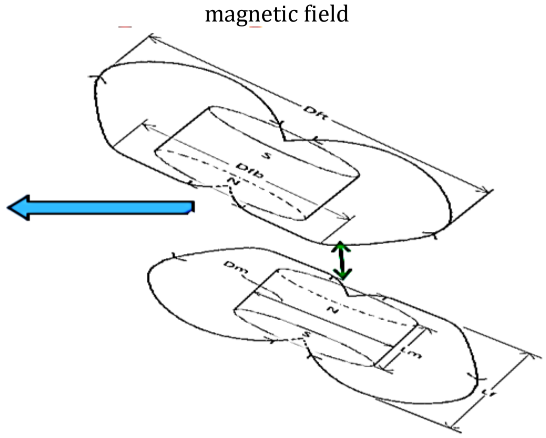
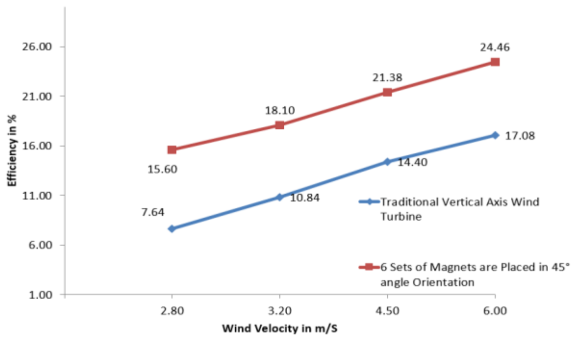


Figure 16: The turbine will encounter more repulsive force while leaving the magnetic field

The Figure 16 is used as an illustration. The restive force produced by magnetic repulsive force will be lessened as a result of the 45 degree orientation, which increased the distance between the magnetic flux density produced by magnets of the same polarity when they were coincident. Figure 16 demonstrates that due to the magnetic flux density produced by the same polarity magnets departing the field being less separated due to the 45 degree orientation, there will be a higher restive force produced by the magnetic repulsive force. So, the wind's mechanical energy is transformed into kinetic energy, which is then fed to the wind turbine.



Graph 1: Graph comparing the effectiveness of PM-propelled VAWT vs conventional VAWT

The PM-driven VAWT exhibited a faster rotation speed than our traditional VAWT, according to this research. For the identical wind speed situation, the regular VAWT only achieved an efficiency of 17.08 percent, whereas the permanent magnet driven VAWT attained a result of 24.4 percent.

III. Findings and Discussion

In this case, the force generated by the permanent magnets can infuse the rotary blade structure with a certain amount of dynamic power while converting wind energy into an alternate kind of mechanical power [8]. In this performance assessment, the static magnet propelled turbine VAWT was shown to have a faster shaft rotational speed than our regular VAWT. The efficiency of conventional VAWTs was about 17.081 percent, but the static magnet driven VAWT had a 24.466 percent efficiency for the same wind speed scenario. Additionally, it was claimed that as the wind blew more slowly, the potency increased. Therefore, while using static magnet dynamical properties, it will also function better when there is less wind. We believe that the PM Propelled Wind Turbine is much more efficient than the concept of solar and wind energy combined because of the aforementioned factors.

IV. Conclusions.

Renewable energy is produced from natural resources that refill more rapidly than they go out. The sun and the wind are two instances of such cyclically renewing sources. We have a wide range of solutions for sustainable energy. There is little doubt that the global power supply will need to be greatly enhanced in the near future in order to keep up with the present growth in human living standards. At the same time, we are aware of the fundamental truth that wind is created as a result of the earth's rotation and uneven heating, which causes temperature variations between day and night. Depending on the temperature of the molecule, heated atmospheric air will rise close to the equator and gradually spread toward the poles of the planet, causing wind. It would seem that using wind power might be a long-term answer to the present global energy problems. The requirements for sustainability have been considered, nevertheless. This means that even if the resource is valuable enough to sustain a range of economic activities in its current technical condition, the realization of vast technological potential might ultimately result in the resource being endless. The kinetic energy that these winds generated is known as wind energy. Other than the synchronization of solar and wind power, not much study has been done on hybrid power technology.

In order to achieve higher efficiency in a vertical axis wind turbine, research and development were done to deploying the magnetic propulsive phenomena as an extra energy source. The availability of wind energy will not be constrained in the future due to climate change and global warming, which help to produce more kinetic energy in the form of wind. Additionally, by taking into account the fundamental characteristics of magnets, such as their attracting and repulsive forces, the thought of a hybrid energy source for wind already seems improbable. The magnetic repulsion feature increased the efficiency of our turbine even in low wind speed situations. As a result, there is a chance to provide.

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