FULL LENGTH PAPER

CONCEPTUAL SIZING APPROACH FOR ELECTRIC POWER GENERATION TURBINE AEROSTAT

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Abstract

Addressing the challenges of increasing global electricity demand and the environmental impact of conventional energy sources requires innovative solutions. This study proposes a practical approach to overcome the limitations of wind power, which is dependent on weather patterns and land constraints. The solution involves using tethered aerostats equipped with wind turbines to generate power. By connecting these aerostats to transmission towers, the system optimizes efficiency and utilizes existing infrastructure. The research explores the design methods, parameters, and complexities involved in implementing this groundbreaking solution, emphasizing the benefits of advancements in wind turbine technology. This self-sustaining energy system offers a reliable and cost-effective alternative for renewable energy generation, reducing carbon emissions and meeting the ever-growing global electricity demand. By paving the way for a sustainable and eco-friendly future in energy production, this solution holds promise for a brighter tomorrow.

Nomenclature

c	= Specific heat capacity
E	= Young's modulus
k	= Thermal conductivity
P	= Rated power
V	= Voltage
v	= Poisson's Ratio
σ_{yield}	= Yield Strength
ρ	= Density

Introduction

The wind is the indirect form of solar energy and is constantly being replenished by the sun. About 10 million MW of wind energy is continuously available on the earth's surface [1]. The concept of extraction of power from wind originated years ago, whether it would have been windmills for pumping water or grinding of grain through an array of blades [2]. The wind turbine converts the kinetic energy of wind to electrical energy through the rotation of blades. Conventional windmills and wind turbines have continually altered and developed to improve the efficiency of their designs. After each advancement, there was only a minor improvement in system output.

Moreover, since wind is slow near the ground, there is low energy output from individual wind turbines in the wind farms. This makes ground-based turbines an inefficient method for large-scale power production. To resolve this problem of unsteady and slow wind close to the earth's surface, another major advancement in this field was fixing the wind turbines on top of a tower. Many wind turbines were placed well above the ground at altitudes up to 120 m because wind speeds increase dramatically with altitude. Power generated by wind turbines does not merely increase linearly with wind speed but by the cube of the wind velocity [3]. Hence, doubling the wind speed increases the available power by eight times. However, the height of the tower is limited because of the building cost involved. To avoid buckling, the tower's height needs to be doubled in addition to doubling of tower's diameter as well, thus increasing the amount of building material by a factor of four. This increases the cost of tower and foundation construction [4]. Another difficulty associated with conventional wind farms is noise pollution, which limits the sizes of wind farms [5].

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All these factors have led to the development of a novel concept which is "Airborne wind turbine" electricity generation. This Airborne Wind Turbine contains lighter-than-air gas, which supplements lift and helps them remain aloft. These Airborne Wind Turbines aim to produce a quantum leap in "environmentally clean" electricity generation.

Literature Survey

Civalier et al. [6] discussed the results of a techno-economic comparison of three concepts for the generation of electrical power using tethered aerostats, viz.,

- Diffuser Augmented Wind Turbine (DAWT) is an ingenious renewable energy solution that enhances traditional wind turbines by incorporating a specialized diffuser structure (Fig.1). Unlike conventional designs, DAWTs feature an enlarged circular ring surrounding the turbine blades. This diffuser accelerates the wind flow as it passes through, effectively increasing the velocity and consequently boosting the turbine's power output. By leveraging this innovative design, DAWTs demonstrate improved energy capture efficiency, making them a promising technology for harnessing wind energy in a more sustainable and effective manner.

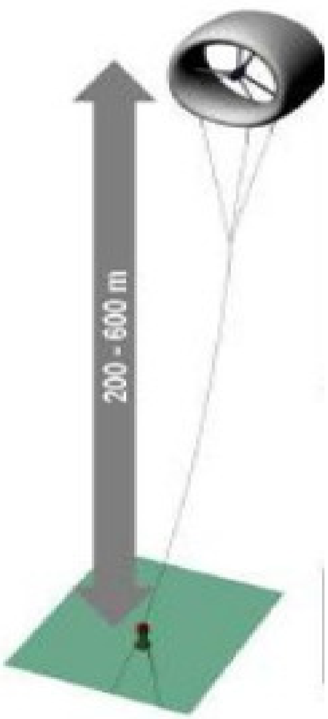


Fig.1 Diffuser Augmented Wind Turbine (DAWT) [18]

- Magenn Air Rotor System (MARS) which is a Lighter-than-air tethered wind turbine rotating along the horizontal axis (Fig.2). Consisting of a helium-filled, aerodynamic balloon with an embedded horizontal-axis wind turbine, it floats at high altitudes, tapping into more consistent and powerful winds. This innovative design allows the MARS to generate clean and sustainable energy while overcoming the limitations of ground-based wind turbines. With its mobility and adaptability, the MARS presents a promising solution for decentralized and efficient wind power generation.
- An aerostat mounted with solar PV cells (Fig.3). This design capitalizes on the abundant sunlight available at

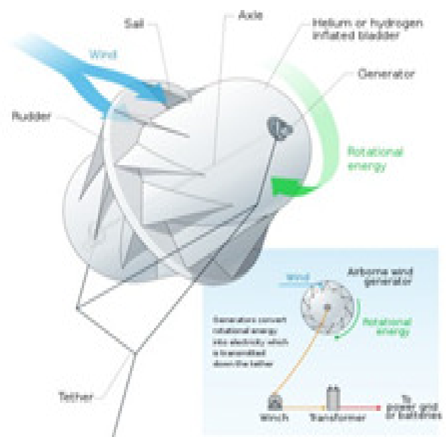


Fig.2 Magenn Air Rotor System (MARS) [7]

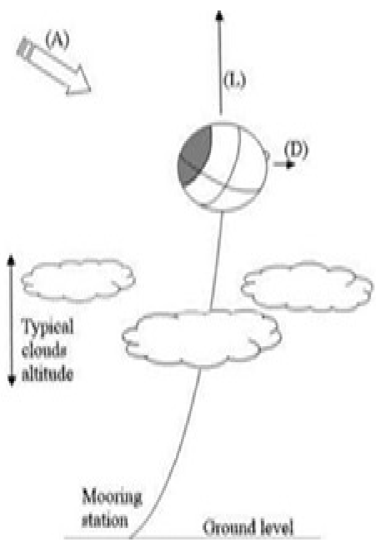


Fig.3 Aerostat Mounted with Solar Cells (Solar PV) [18]

higher altitudes, enhancing solar power generation efficiency. The aerostat serves as a stable and strategic platform for solar panels, enabling prolonged exposure to sunlight. This concept offers a sustainable and reliable source of electrical power through harnessing solar energy in an innovative aerostat-based configuration.

A methodology for conceptual sizing and scaling up the three concepts was also developed capacity.

Vijay Ram and Pant [15] discussed that past studies on shape optimization of airships have looked at the envelope in isolation and have focused only on envelope drag reduction. The study says that the GNVR shape has a higher payload-carrying. Andrew Winslow [8], in his thesis, has compared vertical and horizontal wind turbines in detail. Vertical-axis wind turbines have blades that are perpendicular to the ground and rotate around an axis along the vertical direction. Vertical turbines use lift, drag, or a hybrid of the two components. The first known windmills were VAWTs. However, over time, horizontal mills came into the picture and became common in this field. Because of this change, VAWTs remained on the fringe of development, while HAWTs received most of the attention. VAWTs tend not to be as efficient due to backtracking because their blades move in the same direction as the wind. On every rotation a blade makes, it must travel back into the wind before being pushed back around [9].

Wish Energy Private Ltd

Wish Energy Private Limited [17] is a company that specializes in providing energy solutions to meet the demands of modern society. The aim is to promote sustainable and renewable energy sources to help mitigate the effects of climate change.

Amongst the wide range of energy solutions including solar panels, wind turbines, hydro power, and biogas systems provided by the company, we homed on to wind turbines suitable to our project requirements. They have a range of wind turbine options available, including small-scale turbines for homes and businesses, as well as large-scale turbines for large-scale energy generation projects. Also, the company has a team of experts in wind turbine technology, who can work closely with clients to provide custom solutions that can meet their specific needs.

The present paper studies the methodology to design an Aerostat System under which a Horizontal Axis Wind Turbine (HAWT) will be mounted as depicted in Fig.4. This paper will elaborate upon a novel idea of mounting the wind-based power-generating aerostat system on top of a transmission tower used in an electrical grid system. The area in the vicinity of these transmission towers and the tower itself are of no use for any other purpose other than supporting high-tension power cables. In the concept proposed through this study, the aerostats enabled by wind power generation can be mounted on top of these towers to harness high-altitude wind energy.

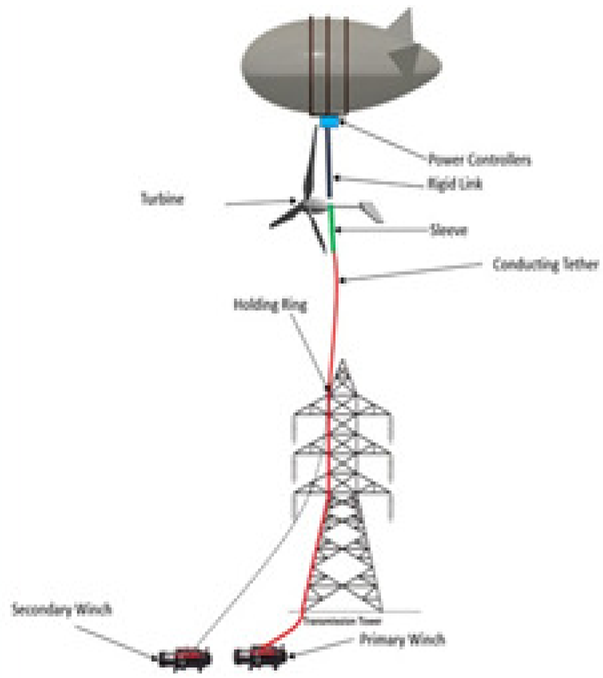


Fig.4 Proposed Design of HAWT Suspended Below the Aerostat

Methodology

The efficiency and effectiveness of an aerostat depends on its design and configuration, which involves the analysis of various sub-sections. One such aspect is exploring how the aerostat envelope shape affects its performance by comparing different shapes. Additionally, the ability of the electrical transmission tower to withstand the load of the mounted aerostat is evaluated. The design of the ring structure is also discussed, as it helps distribute the weight and facilitates placement of wind turbines on top of the aerostat. Finally, a launching sequence system is devised to ensure safe deployment of the aerostat. This chapter provides valuable insight into the critical factors needed to build a successful wind power aerostat system.

Envelope Profile Comparison

To determine the efficiency of the aerostat, the change in factors like volume, surface area of the envelope, length of the envelope, maximum diameter of the envelope is studied. The methodology for conceptual sizing of aerostats is a systematic approach with flexibility in shape, lifting gas, fand design considerations. Parameters like payload, volume, length and surface area are studied [19], selecting from three envelope shapes [15]:

- GNVR which is named after G.N.V Rao which is a combination of ellipse, parabola and circle,
- Oblate Spheroid (OS) formed by rotating an ellipse along its minor axis, and
- Lynx shape which has a streamlined envelope profile with a flat end, each with specific formulae for volume, surface area, and dimensions.

The choice of hydrogen or helium as lifting gas, along with considerations for gas purity and leakage during deployment, is provided. Equations calculate net lift based on input parameters, atmospheric conditions, and gas properties. Both shark fins and inflatable fins are accommodated, with estimations for weight and area. The methodology enables comparison between aerostats of different configurations, facilitating optimization based on factors like system mass, gas leakage, and buoyancy duration. Its iterative nature allows for adjustments until satisfactory results are achieved, providing a comprehensive framework for aerostat conceptual sizing. Based on the studies done, it is observed that GNVR shape aerostat shape possesses a greater volume, larger surface area, more length, less diameter, and smaller cross-section area in comparison to Lynx and OS for a given payload capacity. These results imply that GNVR shape would have lower wind resistance and enhanced aerodynamic stability.

Figure 5 to Fig.7 show the envelope profiles. To determine the efficiency of the aerostat, the graphs show the change in factors like volume, surface area of the envelope, length of the envelope, maximum diameter of the envelope. Based on the graph shown in Fig.8, it can be observed that GNVR aerostat shape possesses a greater

Fig.5 Oblate Spheroid (OS) Envelope Profile

Fig.6 GNVR Envelope Profile

Fig.7 Lynx Envelope Profile

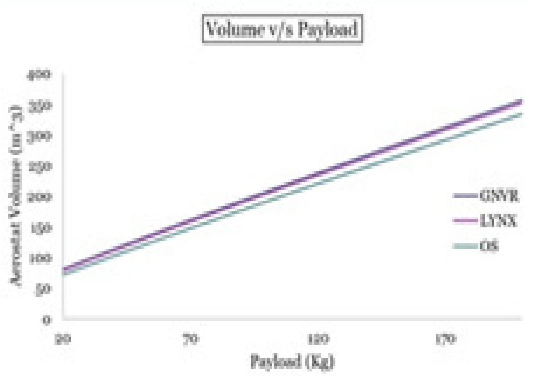


Fig.8 Effect on Volume of the Aerostat Due to Payload

volume in comparison to Lynx and OS for a given payload capacity.

Further, the graphs shown in Fig.9 and Fig.10 demonstrate that GNVR shape possesses a larger surface area and length as compared to the other two shapes when holding a given payload. Additionally, the graph shown in Fig.11 illustrates that maximum diameter of GNVR aerostat is

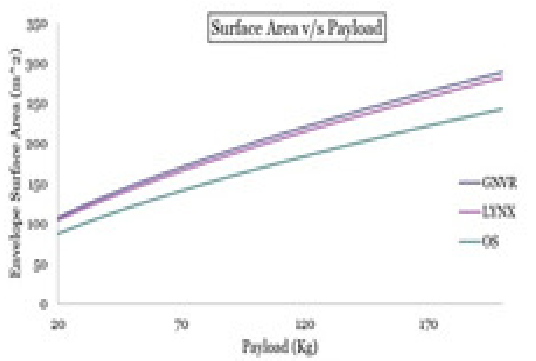


Fig.9 Effect on Envelope Surface Area Due to Payload

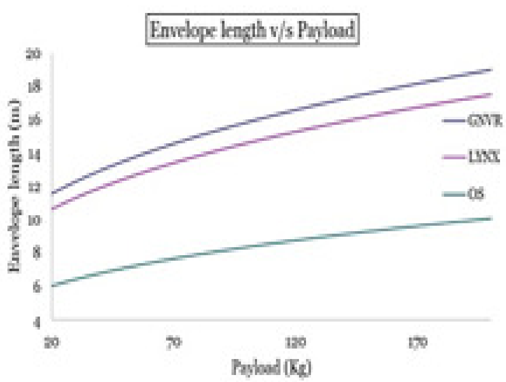


Fig.10 Effect on Envelope Length Due to Payload

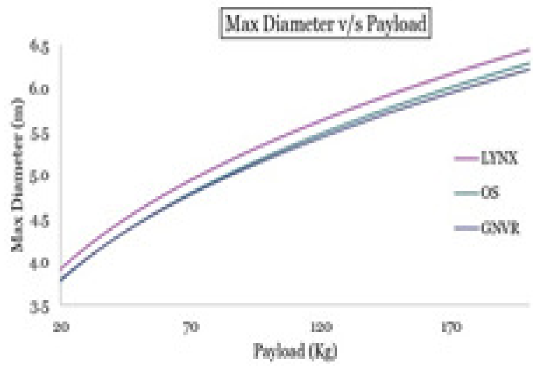


Fig.11 Effect on Max Diameter of the Envelope Due to payload

lower than that of Lynx and OS, implying that it would have a smaller cross-sectional area which in turn, leads to lower wind resistance and enhances the aerodynamic stability of the GNVR shape.

After the comparison studies shown above and considering the shape optimization method given by Vijay Ram and Pant [15], GNVR shape has been finalized for our aerostat envelope design as shown in Fig.12.

Envelope Material

The major component of lift force in an aerostat comprises of the force of buoyancy acting on a large envelope filled with the Lighter Than Air (LTA) gas. Therefore, the principal component of an aerostat is the envelope. In their paper, Adak, and Joshi [16] confirmed that no single fabric

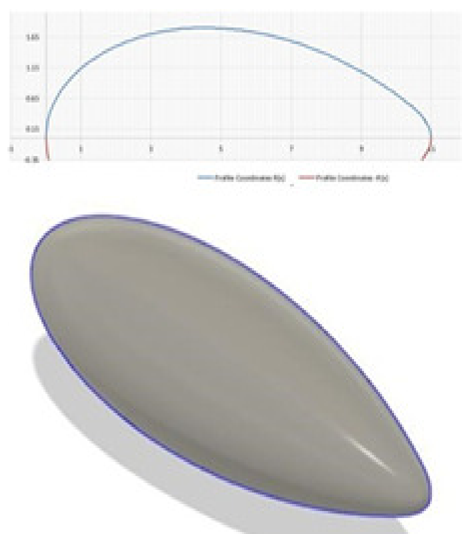


Fig.12 Side Profile Sketch and 3D Model of the GNVR Envelope Shape

or film could fulfil all the requirements posed by the aerostat for a long service life. A double chamber envelope of 125 gsm will be used as shown in Fig.13. The inner layer of the aerostat would comprise of LLDPE (Linear Low-Density Polyethylene) for gas retention, as it has several desirable properties, including high strength, flexibility, and resistance to impact and punctures.

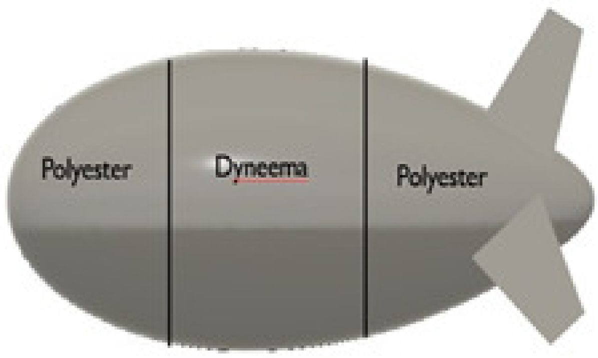


Fig.13 Multi-layer Configuration of the Aerostat

In addition to its strength and durability, LLDPE is also relatively lightweight, which is an important consideration when designing aerostats. These properties make it an ideal material for use in the inner layer of an aerostat, where it can help to retain the gas used for buoyancy. The outer layer is constructed using a fabric made of Ripstop Nylon Polyester, which is coated with Polyurethane (PU) to provide protection against environmental damage. Additionally, Dyneema patches are strategically placed on the outer layer of the envelope to strengthen and increase the load bearing capacity of the envelope at specific locations. Stress concentrations would occur at the areas under the ring structures, due to payload weight and external forces such as turbulence. By placing these patches on the outer layer of the aerostat, it would prevent failure or damage of the envelope.

Transmission Tower

This section discusses the unique idea of harnessing wind energy by mounting wind turbine systems on top of transmission towers, which are commonly used for long-distance power transmission in our country. The transmission grid covers a vast network of over 172,154 circuit kilometres of transmission lines with 262 substations, and their availability is continuously maintained at over 99% using best operational and maintenance methods like aerial patrolling, GIS mapping, UAV/drones, and emergency restoration systems [20].

However, the area around transmission towers is often underutilized. To harness high-height, unobstructed wind energy, the proposed concept involves mounting wind turbines on top of these towers. The structural analysis of the tower has been modelled using STAAD PRO software as shown in Fig.14. For the transmission tower analysis, the material properties typically include parameters such as Young's Modulus, Poisson's Ratio, yield strength, and density, which define the behaviour of the structural elements. Common materials used for transmission towers include steel, with typical values for Young's Modulus ranging from 200 GPa, Poisson's Ratio is 0.3, yield strength of 250 MPa, and a density 7850 kg/m^3 [21]. Loading conditions for transmission towers encompass dead loads, such as the weight of the tower itself and any attached equipment, as well as live loads due to wind and ice. Wind loads, often the dominant factor, vary based on geographical location and tower height, with standards such as ASCE 7 providing guidelines for their calculation [22]. Assumptions in the analysis may involve simplifying the tower structure to idealized models, neglecting minor loads, and assuming linear material behaviour within the elastic range [23]. The results of the analysis are below:

- Maximum structure deflection in X direction due to aerostat mounted with a wind turbine system is only 357 mm.
- The forces acting on the tower, with or without the wind turbine system, under uniform wind conditions, are not significant.
- The tower can adequately support the wind turbine system with specific reinforcements at specific points to ensure safety.

Ring Structure

In the case of turbine aerostat, load distribution is a critical factor in ensuring the safe and efficient operation of an aerostat system, as it reduces the risk of structural failure and increases the overall stability of the system. For resolving the above issue, a multiple ring structures made of fiber composites is proposed which is essential for providing stability and load distribution on the aerostat envelope. These structures are designed to support the payload, and by distributing the load more evenly across the aerostat envelope, they prevent localized stress points

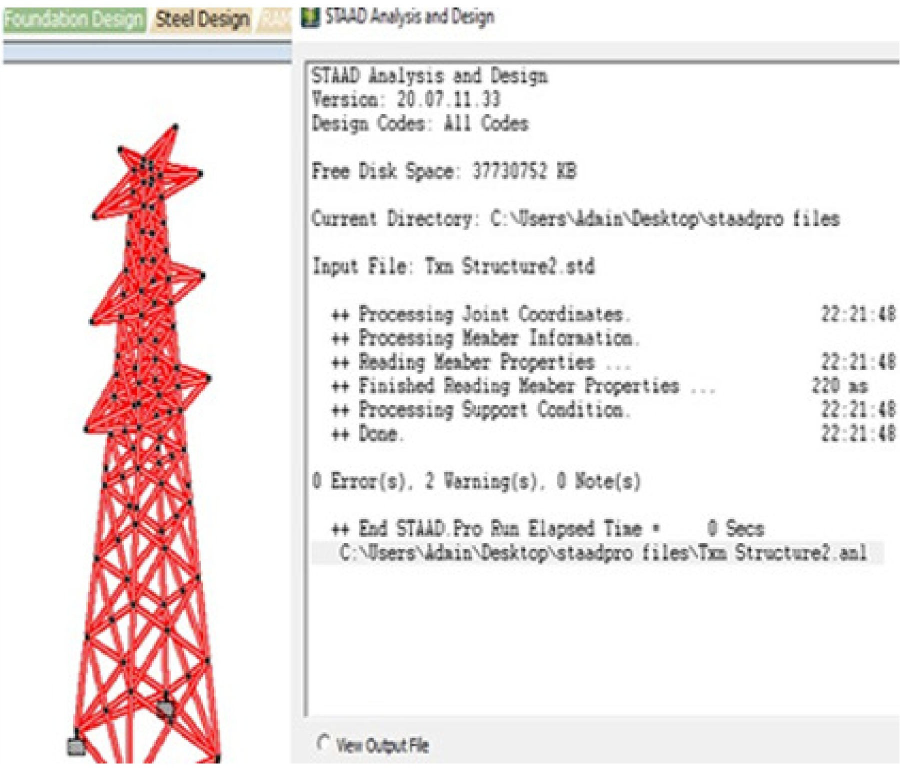


Fig.14 Showing Analyzed Transmission Tower on the STAAD Pro-Software with Zero Errors

that could damage the envelope. Additionally, by using fiber composites, the weight of the ring structures can be minimized, which further enhances the aerostat's performance capabilities, including altitude and endurance. These rings will be supported by links on the bottom of the aerostat envelope, as shown in Fig.15 and Fig.16.

Deploying the Aerostat System

The deployment of the aerostat system is a critical aspect of its operation and must be done carefully to ensure safe and efficient operation. Fig.17 to Fig.20 shows the sequence for the deployment process, which is designed to allow the aerostat to be raised and lowered without

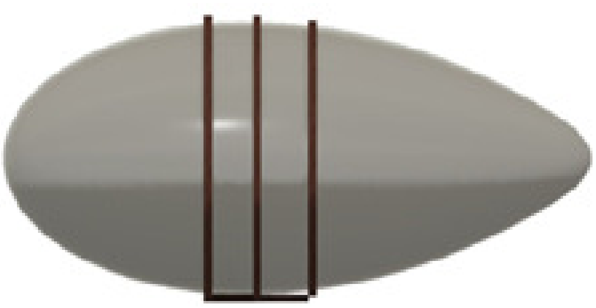


Fig.15 Side Profile of the Aerostat with Ring Structure

Fig.16 Projected View of the Ring Structured Aerostat

requiring the winch to be mounted on top of the tower. This arrangement eliminates the risk of the winch becoming fouled with the power carrying cables attached to the tower.

The first step in the deployment process is to keep the aerostat system grounded using the holding ring A1, as shown in Fig.17. This ring acts as a secure anchor point for the aerostat system, ensuring that it remains in place until installation is complete. Once the aerostat system is securely anchored, the conducting tether, which is shown in red in the figures, is connected to the primary winch.

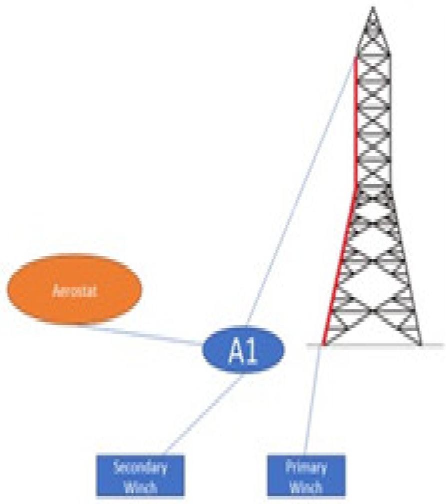


Fig.17 Initial Stage of Installation

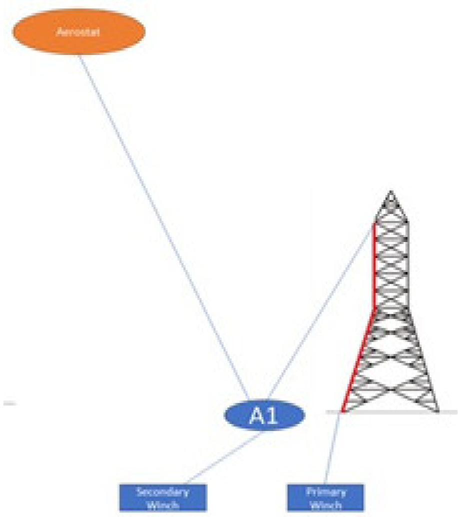


Fig.18 The Aerostat is Inflated with LTA Gas

The primary winch controls the ascent and descent of the aerostat envelope, allowing the system to be raised and lowered as needed. The secondary winch is also involved in the deployment process and controls the ascent of the envelope during launch and recovery. Finally, the holding ring will eventually be attached to the aerostat system, providing a secure anchor point for the system during operation. This will help ensure that the aerostat always remains safely in place, even in windy conditions. By placing LED lights along the tether, the lights will be visible from a distance and will create a well-defined line

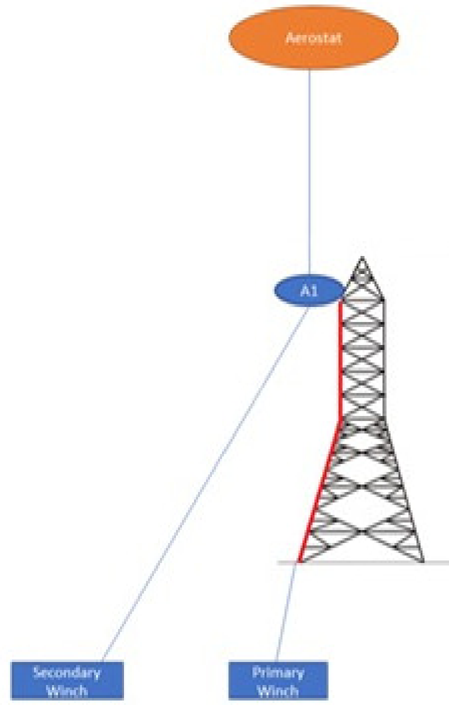


Fig.19 Holding Ring Attached on Top of the Tower

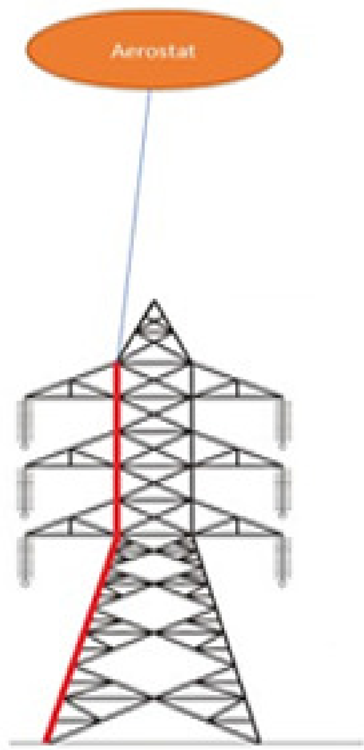


Fig.20 The Aerostat System After Final Deployment

of light that can help guide and alert people to the presence of the transmission tower.

In summary, the deployment of the aerostat system requires careful attention to detail and must be carried out in accordance with the steps explained. This will help ensure safe and efficient operation of the aerostat and avoid any potential issues such as fouling of the conducting tether or other components.

HAWT Specifications

Table-1 shows the general tabulated list of HAWTs, and their specifications manufactured and provided by Wish Energy Solutions Private Limited [17].

Figure 21 shows the energy comparison of wind turbines. Fig.22 shows the power curve for different turbines.

The Windistar 400, which has a rotor diameter of 1.26 m and a rated power of 400W, is the smallest turbine that is currently in production. The wind turbine Whisper 100 belonging to the second category has a rotor diameter of 2.14 meters and a weight of 21 kilograms. Its peak power output is measured at 900 watts. The third tier of wind turbine falls within the medium category, featuring a rotor diameter of 2.72 meters and a weight of 30 kilograms. Its peak power output measures at 1000 watts. Whisper 500 wind turbine classification pertains to a design with a rotor diameter of 4.5 meters and a weight of 80 kilograms, capable of generating a peak power output of 3200 watts. Table-2 presents the tabulated data of the wind turbines manufactured by the company, including specifications such as the rated power output, rotor diameter, and weight of the turbine [16].

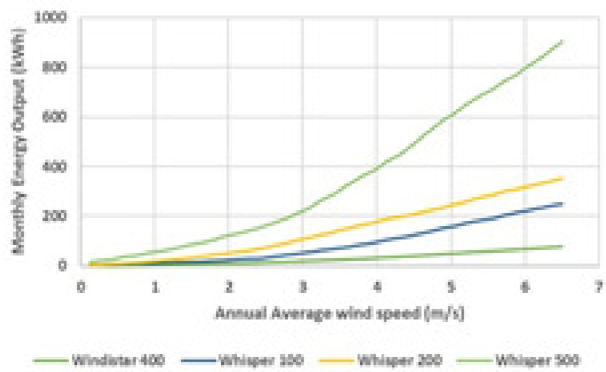


Fig.21 Energy Curve Comparison of Wind Turbine

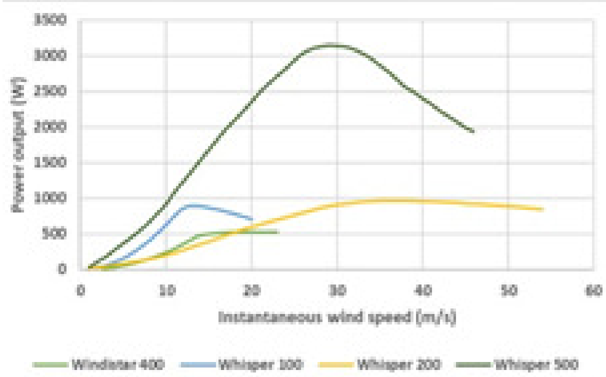


Fig.22 Power Curve Comparison of Wind Turbine

Table-1 : List of HAWT General Specifications Provided by Wish Energy Solutions Pvt Ltd [24]

Turbine Name	Cut in Speed (m/s)	Voltage (V)	Peak/Rated Power @ 12.5 m/s	No. of Blades	Blade Material	Body Material	Survival Wind Speed (m/s)
Windistar 400	3.6	12/24/48	400	3	Carbon fibre composite	Cast Aluminium	50
Whisper 100	3.4	12/24/48	900	3	Carbon fibre composite	Cast Aluminium	49.2
Whisper 200	3.1	24/48/120/240	1000	3	Carbon fibre composite	Cast Aluminium	55
Whisper 500	3.1	24/48/120/240	3200	3	Carbon fibre composite	Power coated MS	55

Table-2 : List of Specifications of all the Turbines Provided by Wish Energy Private Limited

Turbine Name	Peak Power (kW)	Rotor Diameter (m)	Turbine Mass (kg)
Windistar 400	0.4	1.26	6.8
Whisper 100	0.9	2.14	21
Windistar 1500	1.5	2.75	30
Windistar 2000	2	2.75	32
Whisper 500*	3.2	4.5	80
Whisper 500+	3.5	4.5	90
Windistar 4500	4.5	4.6	113
Windistar 5000	5	4.6	117

* 2 bladed turbine and rest are 3 bladed turbine

Comparison of Turbine Specifications

To establish a mathematical relationship between two variables, a trend line is fitted to the data points depicted in graphs shown in Fig.23 to Fig.25. This trendline represents the general pattern or trend in the data and allows us to estimate the value of one variable based on the value of the other. By fitting a trendline to the data, we can obtain a mathematical equation that describes the relationship between the two variables. This equation can be used to make predictions about the behaviour of the variables and to quantify the strength and direction of the relationship. Fig.23 to Fig.25 shows the trend lines of rotor diameter of the turbine, weight of the turbine, rated power and their relation to each other.

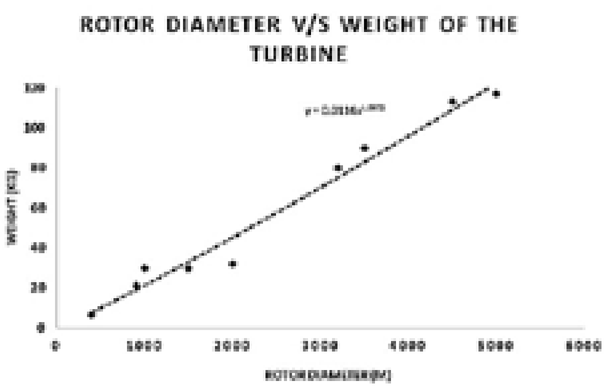


Fig.23 Graph of Rotor Diameter Vs Weight of the Turbine

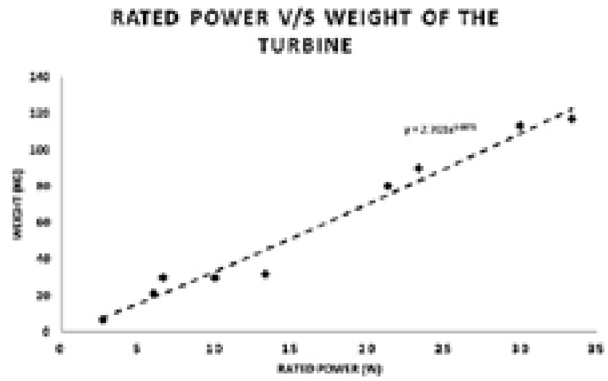


Fig.24 Graph of Rated Power Vs Weight of the Turbine

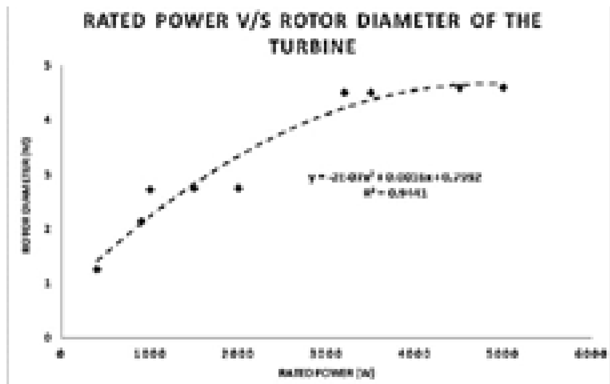


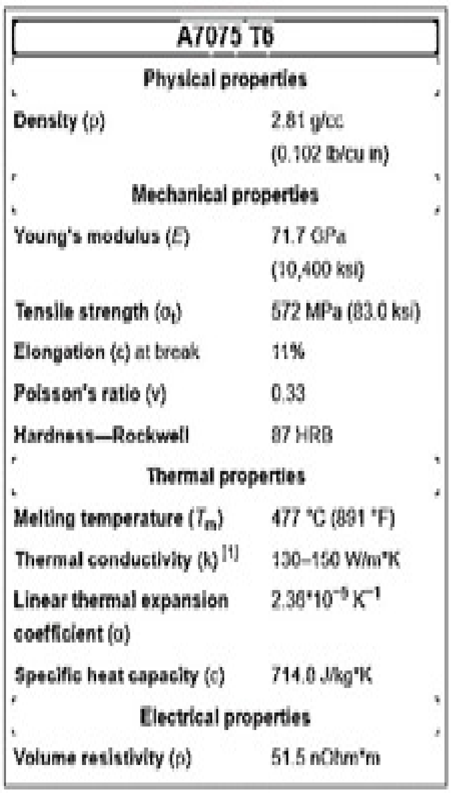
Fig.25 Graph of Rated Power Vs Rotor Diameter

Rigid Pole Mounted Below the Aerostat

Our research indicates that a stiff pole or structure should be mounted below the aerostat on which the wind turbine should be placed. This is to ensure no hindrance caused by the tether when the turbine is functioning. The pole will be mounted in such a way that it has height greater than the rotor diameter. Most of the wind turbines uses Stainless steel (tensile strength of 620.5 MPa, density 7850 Kg/m^3) for pole construction. For Windistar 400, they construct a stainless-steel pole of Outer diameter 1.5 inch which weighs approximately 50 Kg. This calculation is based on the conventional wind turbines mounted on the earth's surface but very heavy if considered for our study. We found an alternative to the Stainless steel which similar Tensile strength but less weight (Higher Strength to weight ratio) which is Aluminum 7075 (Fig.26 and Fig.27) (tensile strength of 572.2 MPa, density of 2810 Kg/m^3).

With the material properties data and the pole dimensions, we estimated the weight of the pole. The height of

Fig.26 Aluminium 7075 Pipe



A7075 T6	
Physical properties	
Density (ρ)	2.81 g/cc (0.102 lb/cu in)
Mechanical properties	
Young's modulus (E)	71.7 GPa (10,400 ksi)
Tensile strength (σ_t)	572 MPa (83.0 ksi)
Elongation (ε) at break	11%
Poisson's ratio (ν)	0.33
Hardness—Rockwell	87 HRB
Thermal properties	
Melting temperature (T_m)	477 °C (891 °F)
Thermal conductivity (k) [1]	130–150 W/m*K
Linear thermal expansion coefficient (α)	2.36*10^{-5} K^{-1}
Specific heat capacity (c)	714.0 J/kg*K
Electrical properties	
Volume resistivity (ρ)	51.5 nOhm*m

Fig.27 Properties of Aluminium 7075 [25]

the pole is considered 1m greater than the rotor diameter of respective wind turbine of which 0.5 m is considered from both directions. Table-3 shows the weight estimation of the pole.

Sleeve

Sleeves are placed below the turbine to give a clearance between the rotor and the tether to prevent the accidental entangling of the tether with the rotor. The length of the sleeve is considered 0.5 m more than the radius of the rotor and the material used will be PVC (Fig.28).

Table-3 : Weight Calculations of the Pole Mounted Below the Turbine

Turbine Name	Rotor Diameter (m)	Pole OD (mm)	Pole ID (mm)	Pole Mass (kg)
Windistar 400	1.26	48.3	41.9	2.9
Whisper 100	2.14	73.0	62.7	9.7
Windistar 1500	2.72	73.0	62.7	11.5
Windistar 2000	2.75	73.0	62.7	11.6
Whisper 500*	4.5	139.7	128.9	35.2
Whisper 500+	4.5	139.7	128.9	35.2
Windistar 4500	4.6	139.7	128.9	35.8
Windistar 5000	4.6	139.7	128.9	35.8

* 2 bladed turbine and rest are 3 bladed turbine

Fig.28 PVC Pipe

Results

Aerostat Sizing w.r.t Payload of the Turbine Aerostat

The Wish company provided data on the power generated by a wind turbine, which ranged from 0.4 kW to 5 kW, along with their respective weights. The relationship between the total aerostat payload to Volume of the aerostat is found by considering the buoyancy force created by the gas in the aerostat and total payload mounted on the aerostat [19]. Additional payload components such as a rigid pole mounted below the aerostat, a ring structure, a sleeve for the tether, and other miscellaneous devices were taken into consideration. The equation for Buoyancy force and Payload are as follows:

$$F_{buoy} = \left(\rho_{air} - \rho_{gas}\right) \times g \ V_{total}$$

$$F_{payload} = m_{payload} \times g$$

where F_{buoy} is the buoyancy force, F_{payload} is the Payload force, ρ_{air} is the density of air, ρ_{gas} is the density of the lifting gas (such as helium), g is the acceleration due to gravity, m_{payload} is the mass of the payload and V_{total} is the total volume of the aerostat. Equating the buoyancy force to the payload force achieves equilibrium ($F_{\text{buoy}}=F_{\text{payload}}$). This allows the aerostat to uplift the total payload attached to it. Thus total volume of the aerostat in terms of payload mass will be:

Table-4 shows the total payload and volume of the aerostat for each turbine from Table-2. Six hours of operation is considered for the calculation. Wind speed of 12.5 m/s is considered for the data.

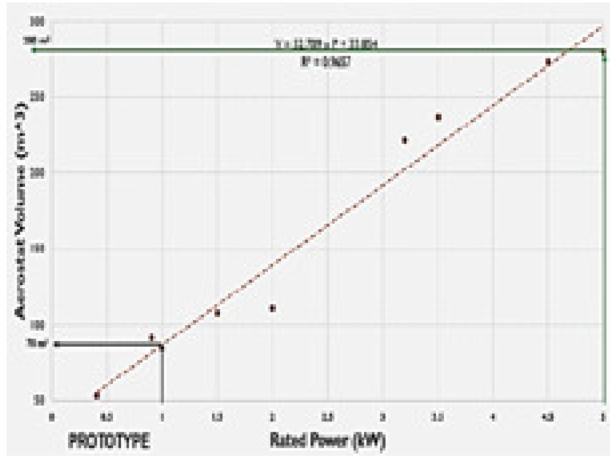


Fig.29 Graph of Aerostat Volume Vs Rated Power of the Turbine

Table-4 : Payload of the Aerostat and Volume of the Aerostat Table for Different Turbines

Weight of the Turbine (Kg)	Weight of the Pole (Kg)	Weight of Turbine +Pole +Sleeve	Weight of the Structure	Total Payload (Kg)	Volume of the Aerostat
6.8	2.9	9.7	7.33	23.0	53.68
21	9.7	30.7	11.44	48.1	91.39
30	11.5	41.5	13.55	61.0	108.06
30	11.6	41.6	13.57	61.2	108.20
32	11.6	43.6	13.96	63.5	111.29
80	35.2	114.2	27.95	149.2	221.91
90	35.2	125.2	29.90	161.1	237.35
113	35.9	148.9	34.52	189.4	273.86
117	35.9	152.9	35.30	194.1	280.04

Figure 29 shows the graphical representation of the relationship between the aerostat volume and the rated power of the turbine. A trendline was included in the graph to estimate an equation that relates the aerostat volume to the rated power of the turbine. This approach provides a scientific and systematic method for assessing the appropriate aerostat volume required for a wind turbine of a certain power rating, while also considering additional payload components.

The largest volume of the turbine aerostat is 280 m^3 which can produce 5 kW. For a smaller system, we could fabricate a 70 m^3 aerostat which can produce 1 kW power output.

Conclusion

This study proposes the use of tethered aerostats with HAWT mounted under it as a renewable energy source mounted on transmission towers to enhance efficiency and exploit existing infrastructure. By harnessing wind energy independently, this system provides a more dependable and cost-effective solution for renewable energy production, potentially decreasing carbon emissions while satisfying the mounting demand for electricity worldwide. The paper examines the design strategies, parameters, and challenges involved in implementing such a system, highlighting the benefits of advancements in wind turbine technology. GNVR shape was considered as the envelope shape and multi-layer configuration is selected. Critical design considerations for the aerostat configuration, such as tower capability, and launching sequence system, are explored. Results show that the proposed solution has the potential to increase renewable energy capacity and reduce carbon emissions while making use of the existing infrastructure. For a power requirement of 5 kW, volume of aerostat needs to be 280 m^3 and a 54 m^3 aerostat can support a payload of wind turbine which has a power output of 0.4 kW.

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