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ELECTRICAL POWER GENERATION USING KITES

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Abstract:
Due to increase in load demand, the generating capacities should be increased and preferably renewable sources are chosen. In this renewable source, wind energy is the one of it. So, we choose the generation of electricity by kites using Wind energy.
Electricity produced by kites in the wind could be inexpensive. We estimated the prices to be comparable with generating electricity using coal power, and half that of using wind turbines. So, we found this useful and this even adds to the conservation of energy. Use of Energy Kites opens a new world of opportunities in the field of wind power generation by making complete use of air at high altitude too.

If such technology is implemented on a large scale, the use of power plants that burn out conventional resources could be decreased to a great extent, thereby decreasing air pollution. Use of this clean energy will decrease the rate of global warming significantly.

Keywords: kite control unit, sensor unit, floating turbine, generator.

1.Introduction:

Storms and natural disasters resulting from extreme weather events are the most common causes of power outages (Campbell, 2012). The coast of North Carolina is particularly susceptible to these types of power outages with an average of two tropical storms or hurricanes affecting NC annually (North Carolina Climate Office, 2019). This past fall, when Category 1 Hurricane Florence hit the coast of North Carolina and continued its path across the state, over 900,000 homes lost power between the middle of the state and the coast. Typically, when homes are without power for days at a time, backup diesel generators are used in order to power household appliances and provide temporary relief from the effects of the storm. Generators can last several days and are useful for keeping households comfortable and functional during major storm events when the power goes out. However, because generators require a fuel source that is typically gasoline or diesel, there are adverse environmental effects with the emission of carbon dioxide, nitrous oxide, and particulate matter. Major storm events and power outages are inevitable, so finding a more alternative that performs similar functions to a backup generator would help reduce an individual's fuel costs and carbon footprint. One of the driving forces behind this research is to further develop an already existing renewable resource. The most feasible and relatively reliable renewable resource during a storm event is wind. Additionally, wind is abundant on the coast of North Carolina, averaging 4.2 m/s in the heavily populated Wilmington area, for example .

During extreme storm events like a hurricane, these wind speeds are even more severe. To date, considerable research has been conducted to construct and deploy airborne wind energy systems (AWES). These apparatuses usually take up less land area than standard wind turbines, which is ideal for implementing a single energy system unit at one's home. Additionally, less materials are needed, thereby reducing the cost per kWh produced. Ultimately, the team's goal was to construct an energy system that is accessible in both portability and affordability. Portability ensures ease of assembly and storage so that it does not occupy a considerable amount of space when not in use. The

AWES is to be constructed out of many of the components that make up a tent, namely poles and polyester fabric. Ideally, the AWES should be , mobile, and durable. Setting up the AWES should be as simple as pitching a tent. Affordability is also a large focus of this project, so greener portable energy can be more accessible.

Electricity produced by kites in the wind could be inexpensive. We estimated the prices to be comparable with generating electricity using coal power, and half that of using wind turbines.So, we found this useful and this even adds to the conservation of energy.Use of Energy Kites opens a new world of opportunities in the field of wind power generation bymaking complete use of air at high altitude too.If such technology is implemented on a large scale, the use of power plants that burn out conventional resources could be decreased to a great extent, thereby decreasing air pollution.Use of this clean energy will decrease the rate of global warming significantly.
Kites extract energy from higher altitudes (typically up to a few hundred meters, although some fly much higher), where the wind blows more strongly, more constantly and with less turbulence. Kites fly very fast across the wind and therefore sweep a large area. A relatively small kite surface area can therefore generate significant lift and power. This means that kites weigh a small fraction of a wind turbine of equivalent annual energy.Flexible deployment: Kites are smaller, lighter, modular, foldable and much easier to handle and transport than conventional fixed turbines.Less infrastructure: The force in the tethers is predominantly a shear force at ground level, not an overturning moment; this makes it highly suitable for deployment in remote areas or poor ground conditions, where short pin piles are sufficient to secure the base station, without the need for huge excavations and mass concrete foundations.
The environmental impact and footprint of kites is much lower.

The following contribution is presented in this paper:
- Low-cost electricity generating.
- Easy to transport and setup anywhere.
- It requires less space.
- It is easy to monitor and control.

2.Literature Survey:

Though kite powered wind energy has not until recently become a popular concept, its principles and had contemplated the use of kites to provide mechanical energy as far back as 1825 but was limited by lack of advancement in the field of aerodynamics at the time. Extrapolating his results to technology similar to sophisticated wind turbines, Loyd estimated that a 2000m2 kite flying at 1200m could produce 45MW (for comparison, the average production of an industrial coal power plant is about 667MW). . The goal of this work was to “experimentally demonstrate that systems employing kites can be used to convert wind energy into useful potential have been considered for almost thirty years. In 1979, Loyd8 investigated the potential for kite powered energy. According to Loyd, G. Pocock mechanical energy.”
Even though wind power generation is growing,there are a number of shortcomings of current generating techniques using wind mills.In particular,windintermittency,costlyandeasily,damaged machinery and large usage requirements are some of the problems that need to be overcome. A relatively new idea for wind power generation that can overcome many of these shortcomings uses large

kites to extract power from higher altitudes.currently ,either kites or fully automatic sailplanes are being tasted.kites have an advantage in that only a minimum number of material has to be airborne to harness energy.sailplanes equipped with sensors are more complicated,but easier to control and more stable in producing power.

3.Components used:

(a) Kite:

A kites' surface converts the motion of the wind into lift or motion of the kite. Conventional methods for power generation using a kite have involved mounting turbine to the kite. Moreover, some methods include the kite pulling its tether which in turn pulls on a generator producing power. In this project an entirely new perspective on Airborne Wind Turbines (AWT) will show the potential of kite based wind energy

(b)Kite control unit:

On-board angle-of-attack mechanisms were used in the 2000 altitude record-making flight; the operators' designed adjuster limited kite line tension to not more than 100 pounds by altering the angle of attack of the kite's wing body. The kite's line had a control: a line payout meter that did not function in the record-setting flight. However, some special tether line lower end used bungee and pulley arrangements to lower the impact of gusts on the long tether.

(c)Sensor unit:

Magnetic speed sensors rely on a magnet as the sensing element or sensed target to capture rotational or linear speed. They are typically used as gear tooth speed sensors or incorporated into stroboscopes or tachometers.

(d)Battery module:

When it comes to battery modules, two other words often come to mind: battery cell, battery pack. In fact, battery is a generic term for all three, while battery cell, battery module and battery pack are different forms of batteries in different stages of application. The smallest of these units is the battery cell, several cells can form a module, several modules can form a battery pack by adding BMS and other management systems.

(e)Generator:

There is a simple concept that demonstrates the generation of electric currents. It involves connecting an electric conductor (wire) to the different poles of a permanent magnet. This wire is then moved through the invisible magnetic field around the magnet.Now, there is a more pragmatic approach to this. All you need to do is bend a wire into a loop and put it between the two poles of a magnet.You can go ahead and cause the wire loop to continually rotate in between the magnet. Current is then induced within the magnetic field.

(f)Floating turbine:

Floating wind turbines are offshore wind turbines that are put on a floating frame to generate power in sea depths where fixed-foundation turbines are not viable. Floating wind farms have the potential to greatly enhance the amount of sea area available for offshore wind farms, particularly in nations like Japan that have limited shallow waters. Wind farms located further offshore can also help to reduce visual pollution, improve fishing and shipping channels, and reach stronger and more constant winds.

(g)Tether:

High-altitude wind energy power generation by kites is considered. A tether connects the kite with an electric generator on the ground. The basic crosswind motion law of Loyd is refined by taking into account the effects of the kite's control and gravity. The influence of the tether sag on the kite angle of attack is also studied improving the previous models of a tightly stretched tether.

4. Existing Methodology:

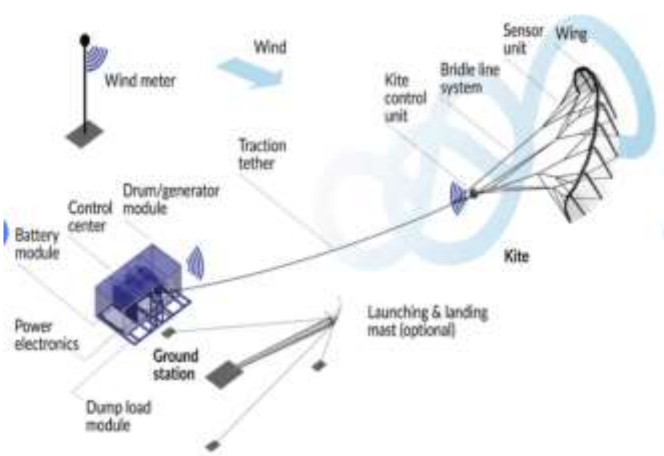
Even though wind power generation is growing,there are a number of shortcomings ofcurrent generating techniques using wind mills.Inparticular,windintermittency,costlylandeasily,damaged machinery and large usage requirements are some of the problems that need to be overcome.A relatively new idea for wind power generation that can overcome many of these shortcomings uses large kites to extract power from higher altitudes.currently ,either kites or fully automatic sailplanes are being tasted.kites have an advantage in that only a minimum number of material has to be airborne to harness energy.sailplanes equipped with sensors are more complicated,but easier to control and more stable in producing power.

5.Proposed Methodology:

Two kites are tethered to a spool as they soar at speeds of around 100 miles per hour in figures of eight,they pull cables which turn the drum,rather like an unrolling spool of thread.The kite tethered to ground,flies in a crosswind direction.After achieving certain altitude this kites obtain a circular projectory.The energy in the wind turns two or more propeller-like blades around a rotor.the rotor is connected to the main shaft,which spins a generator to create electricity.The power generated by the energy kite is transmitted to ground simultaneously.As one kite descends,the other rises,so electricity is generated continuously.

Below is a labeled photograph of our final kite power system (attached to an electrical system designed by separate IQP project).The kite power system consists of a commercially available kite-boarding kite and tethers (1), a wooden A-frame, an aluminum rocking arm mounted at a series of pillow blocks (4), an angle of attack mechanism (3), a roll stability mechanism (2), and the power conversion system (5).

The kite (1) is attached to the end of a rocking arm at (2). A roll stability mechanism autonomously ensures that the kite flies in a stable cycle. This mechanism works by rotating the kite’s control bar as a reaction to lateral motion. As the rocking arm is lifted up, it in turn pulls a spring loaded rope. The rope turns a shaft and a system of gears and belts with a gear ratio of 6:1 transmit this energy to another shaft. The second shaft attaches to an electrical generator and also contains a flywheel to maintain its motion while on the down-stroke (5). Once the rocking arm has rotated to a given angle, a weight in the angle of attack mechanism slides down, pulling the kite’s trailing edge controls and stalling the kite. As the kite stalls and stops producing lift, the arm falls due to gravity and the angle of attack mechanism resets the trailing edge lines to their original tension. The kite again produces lift, restarting the cycle again. This system has successfully been tested by component and as a whole in a battery of lab and field tests.



Two kites are used for the project. Both are Peter Lynn kites from a well known manufacturer and supplier of kite boarding kites, with the primary difference between them being the size. The larger kite initially used by the team had a span from wingtip to wingtip of twenty feet with a chord length of five feet. The smaller kite had a span of fifteen feet with a chord length of four feet. Both kites used for the project used a similar control scheme, consisting of a four line setup with two lines attached to the leading edge and two lines attached to the trailing edge. These are attached to a control bar mechanism as shown.

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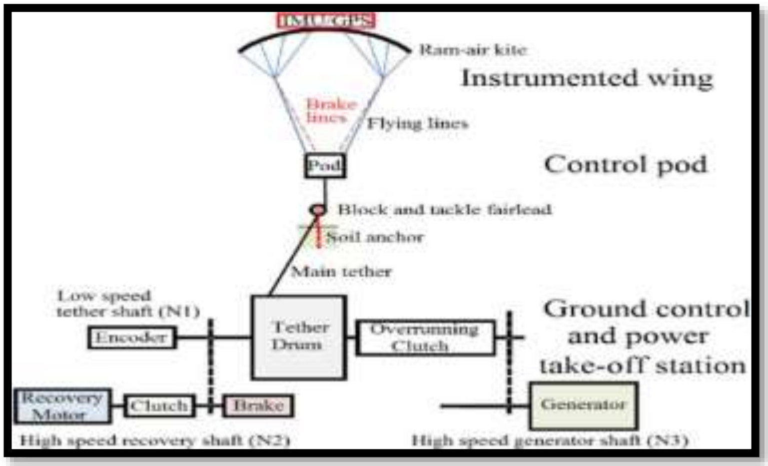
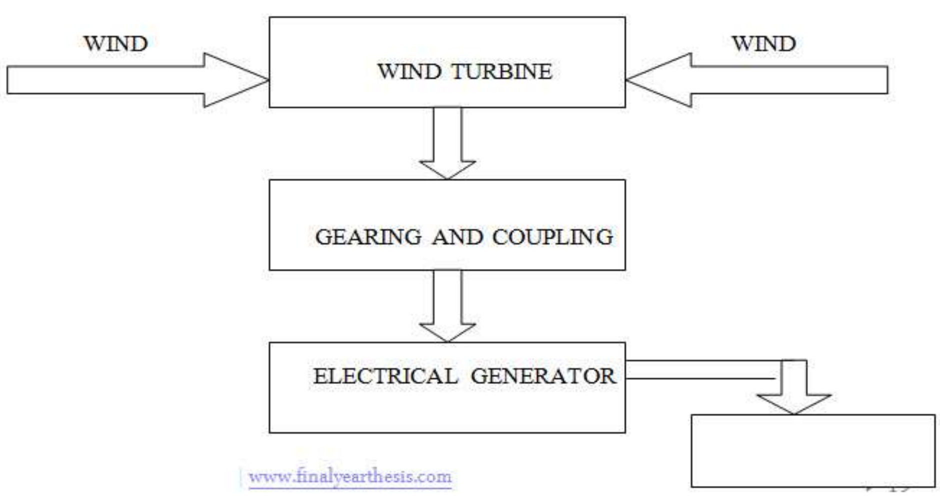
The two center lines are the leading edge lines. These lines experience the highest amount of tension as most of the lift generated by the kite is translated through them to the ring, which for kite boarding would be anchored to the kite boarder. For the kite power system, this 21 line is anchored to the rocking arm. The two outer lines are the trailing edge lines. These lines are under far less tension than the leading edge lines and are the primary means of controlling the kite.

Power conversion system:

Using the control bar, the kite boarder is able to vary the angle of attack of the kite as well as maneuver its lateral (side-to-side) motion within the power window. The power window is the area in which the kite is able to operate. This is the center 45 degrees of a half-hemisphere volume downwind from the kite anchor point on the rocking arm. Lateral control is achieved by simply rotating the control bar, causing the kite to bank and move in the specified direction. The angle of attack is controlled by moving the control bar in and out while keeping the bar horizontal. Pulling the control bar all the way towards the user, as shown in Figure 7, pulls the trailing edge lines in, increasing the angle of attack so that the kite stalls. At this point the kite is "depowered". As the control bar is moved outward, the angle of attack decreases and the lift generated by the kite increases. The kite is fully powered, generated the maximum amount of lift, when the control bar is approximately three quarters of the way out, which can be seen in Figure 7. Moving the control bar beyond this point is referred to as "auto-zenithing." In this mode, the kite has very little pull and flies almost directly overhead with little or no user input. In order to achieve the goal of autonomous power generation, a mechanism had to be designed to control the lateral motion of the kite. With no control input, disturbances such as wind gusts can cause the kite to move to the side, as shown in Figure .



BLOCK DIAGRAM OF WIND POWER GENERATION



6.Conclusion:

The team's proposed AWES solution will allow for those people to sustain their lifestyles temporarily and survive until they get their power back after a severe storm event, such as a hurricane. There have been other solutions created to try to combat this issue, however the one described in this report provides an affordable option with multiple benefits and a considerable amount of energy. The simple setup of the base system connected to the retractable Savoniusstyle kite can be assembled by most and can be deployed in a backyard or on top of a roof. The data acquired from testing smallscale models of the AWES shows that the prototype can generate energy in both typical and heightened coastal wind speeds, and could thus be a reliable source of electricity as a fullscale model. The principal findings demonstrate the usefulness of a kite turbine as a proofofconcept. However, while anidea worth exploring, it is still very much underdeveloped in its current design.

The focus of the design places emphasis on the aerodynamics of the kite turbine, its manufacturing plan, and how well it works to harvest energy. But, this design needs a thorough reiteration phase and power generation plan to be implemented at a larger scale. During testing, the fabric pockets had a tendency collapse and cause the kite to stall. An alternative solution to the cross geometry for the frame would be to make a grid. For example, there could be a number of steel cables running left to right and up and down to form a grid that would prevent the backfacing vane from collapsing completely in heavy winds and stalling the kite. Mass manufactured solutions to this include using chicken wire or wire mesh. Another reason for kite stall was due to the torque placed on the rotor from each vane as the kite rotated and faced the wind. A solution to this would be to not have rotational symmetry between the kite vanes, causing a torque imbalance on the rotor and encouraging the rotor to spin in one direction.

7.Future scope:

Ideally, this model would be tested with a surf kite, tethers with carabiners and tether rings, and a power generation system (base, battery, regulators, waterproofing, etc.). Given the size of the tethers and the nature of the surf kite, ideal locations include the coastline or an open field on a windy day. The current design for the kite turbine involves tent poles, polyester fabric with steel wire to form the pocket shape, 3D printed corners, and a waterproof shipping tube with a 4 inchdiameter. The shipping tube will be used to ship the materials to their destination and then will become the center of the turbine, thus making the fullscale system as portable as possible. The elastic cord that comes with the tent poles will be used to keep the vanes in compression and keep the kite vanes rigid. An alternative option to replace 3D printed elbows would be mass manufactured elbows. Although there is merit in testing smallscale prototypes, testing a fullscale design is the only method to ensure feasibility and workability. In terms of electrical design, the power generation should have a compatible charging/battery system or another method of transferring electricity.

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