

Airborne Wind Energy: Optimal Locations and Power Produced

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Abstract: *Wind Energy is a renewable form of energy available to us humans in abundance. Having many conventional wind energy harnessing techniques available, we could not fight with the problems associated with the death of birds and humans, and the land area required to set up these harnessing plants, therefore a solution was found with airborne wind energy which overcame the problems associated with the conventional methods and produced more power as well. Airborne wind energy can be understood as a design concept for a wind turbine with a rotor supported in the air without a tower, thus benefiting from more mechanical and aerodynamic options, the higher velocity and persistence of wind at high altitudes, while avoiding the expense of tower construction, or the need for slip rings or yaw mechanisms. A criterion is introduced to identify and characterize regions with wind speeds in excess of 36 km/hr occurring at least 15% of the time in each month for heights below 3000 m AGL. These features exhibit a jet-like profile with remarkable temporal constancy in many locations and are termed here "wind speed maxima" to distinguish them from diurnally varying low-level jets. Their properties are investigated using global, 40 km-resolution, hourly reanalyses from the National Center for Atmospheric Research's Climate Four Dimensional Data Assimilation, performed over the 1985–2005 period. If an intermediate number of AWE systems per unit of land area could be deployed at all locations exhibiting wind speed maxima, without accounting for possible climatic feedbacks or landuse conflicts, then several terawatts of electric power ($1 \text{ TW} = 10^{12} \text{ W}$) could be generated, more than enough to provide electricity to all of humanity.*

Keywords: *Airborne, Wind Energy, High Velocity, Electric Power.*

I. Introduction

With the rapid increase in demands, the need for fuel also increases manifold. Earth's crust cannot be the only source to rely on when it comes to energy. According to a fact, earth is 46 billion years old, let's assume it just turned 46 years old, we came 4 years back and industrial revolution started around a year ago, and the usage of earth resources can be summed up to be used around 90% in just a single minute, therefore earth's crust can not be the only source for producing energy. With the growing increase in the demand for alternate sources of sustainable energy worldwide, wind power is gaining importance across the globe. Wind energy currently accounts for nearly half of the clean energy produced worldwide and is predicted to grow 25% each year. Therefore, introduction of airborne turbine will bring relief to earth's crust along with a longer human existence. Airborne turbine has been developed as world's first commercial airborne wind turbine, which uses a helium-filled shell to float as high as a skyscraper and capture the stronger, steadier winds available at that altitude, causing comparatively less deaths to fauna at that altitude. Not just electricity, but BAT can also help to give access to internet to all the areas in the world.

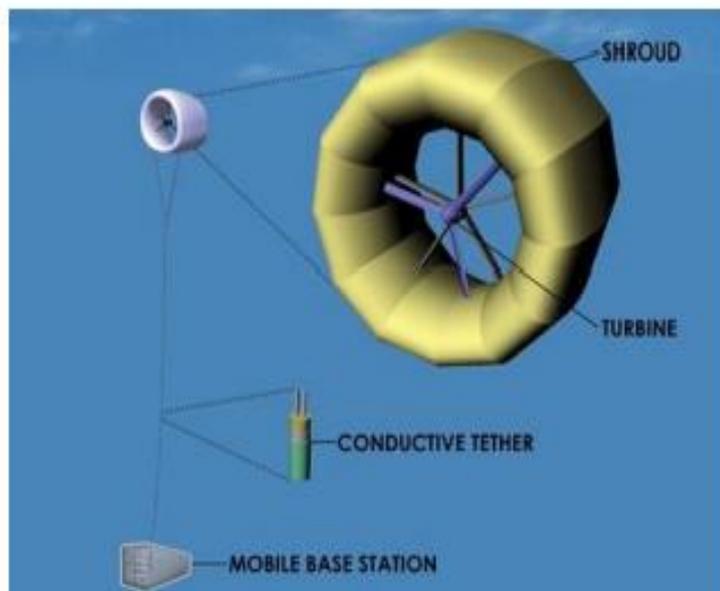
Proven to produce double the energy of similarly sized tower-mounted turbines, the system, called Buoyant Air Turbine (or BAT), is now commercially deployment in rural Alaska, to produce enough electricity for more than a dozen families living off the grid.

BAT can be understood as a 35-foot-long inflatable shell made of the same heavy-duty fabric used in blimps and sails, the BAT hovers 1,000 to 2,000 feet above ground, where winds blow five to eight times stronger, as well as more consistently, than winds at tower level (roughly 100 to 300 feet).



Three tethers connect the BAT to a rotating ground station, automatically adjusting its altitude to obtain the strongest possible winds. Power generated by the turbine travels down one of the tethers to the ground station before being passed along to microgrids. Therefore, the working of BAT can be also be understood as a combination of kite and balloon, and the kytoon (a compressed name for kite and balloon) is kept aloft by steady breezes. Airborne wind turbines are secured to the ground using electrically conductive tethers, which transmit energy to the ground.

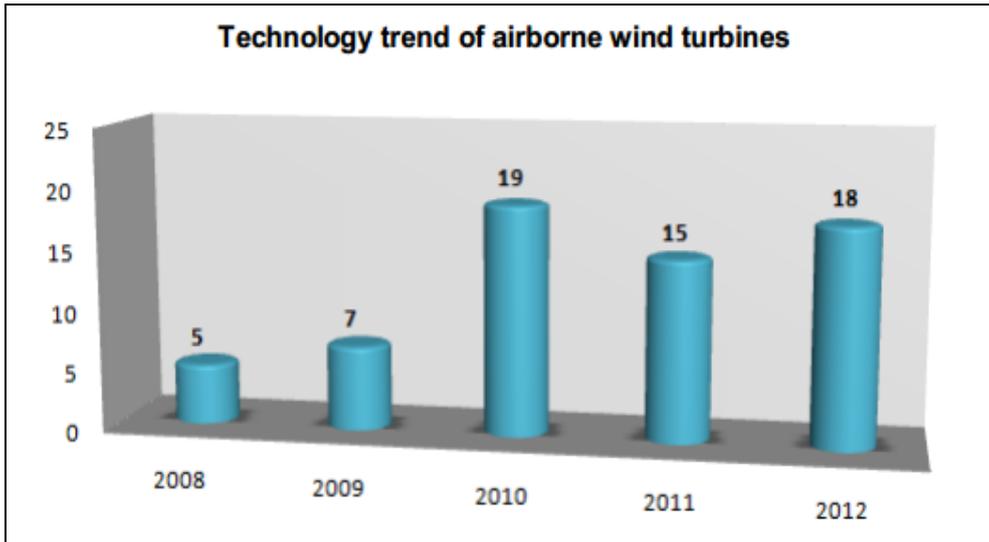
Airborne wind turbine



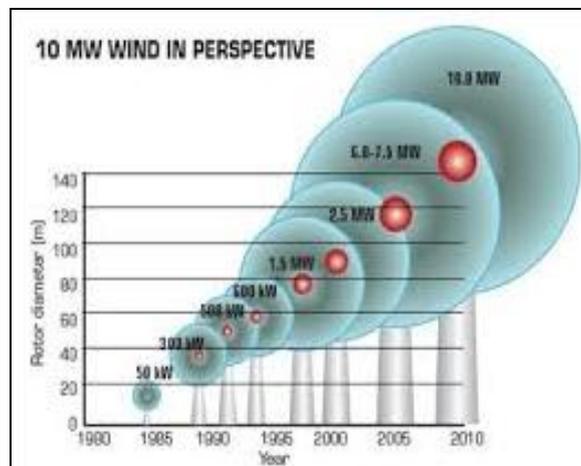
The different methodologies used in AWTs to convert wind energy into electricity are:

- Employing an aircraft, similar to an airplane, with several propellers that serve as wind turbines, flying at high altitudes
- Flying generators suspended using balloons
- Using a blimp, a lighter-than-air, pressurized airship comprising a gas-filled elliptical bag for propelling

Though airborne wind turbine technology innovations started during 1970's, its effective evolution was during 2008-2009. In the year 2010, AWT technology innovations recorded a remarkable growth of 35%, compared to 14% in the previous year. However, the growth phase has declined in 2011 and 2012. Nevertheless, in the following years, there are possibilities of some more interesting innovations.



The BAT, which has a capacity of 30 kilowatts, aims to drop that kilowatt-hour cost down to roughly 18 cents. Since it works at higher altitudes having high velocities of wind blowing, the power so generated is more. Conventional turbine construction, for instance, requires tons of concrete and the use of cranes, which can be difficult to maneuver around certain sites. The modular BAT, packs into two midsize shipping containers for transport and can just be inflated out and self-lift into the air for installation.

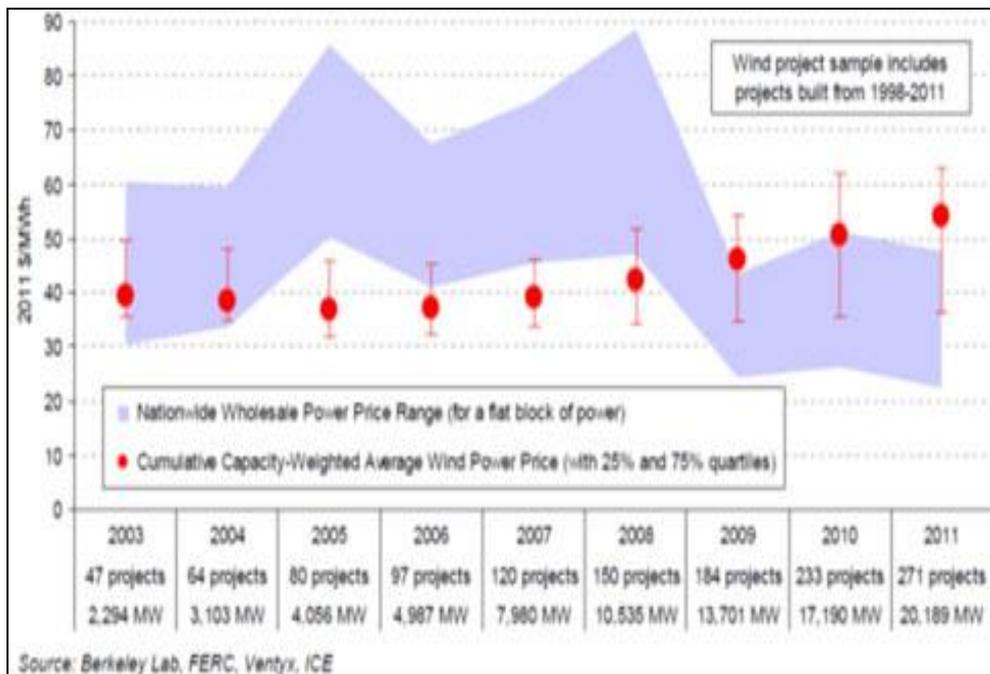
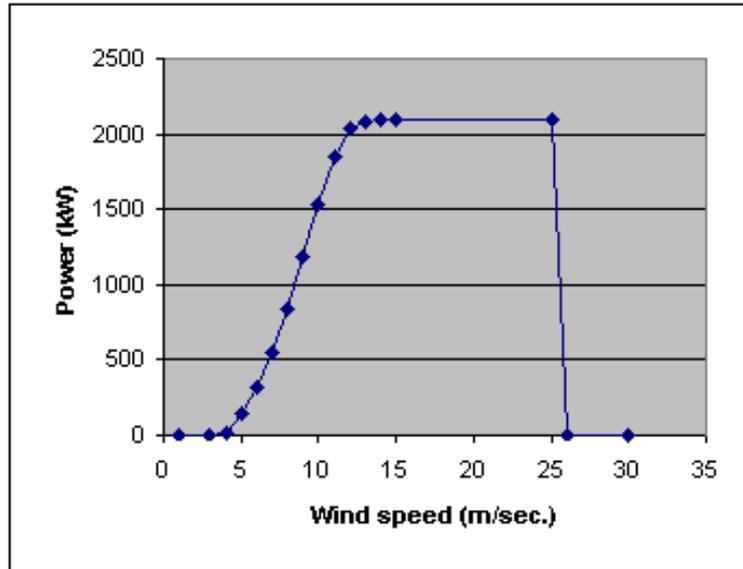


But despite its efficiency, the BAT is not designed to replace conventional tower-mounted turbines, instead its purpose is to bring wind power to remote, off-grid areas where towers aren't practically or economically feasible. Target sites include areas where large diesel generators provide power — such as military bases and industrial sites — as well as island and rural communities in Hawaii, northern Canada, India, Brazil, and parts of Australia. The BAT could also provide power to places blacked out by natural disasters, as well as at amusement parks, festivals, and sports venues.

Much of the BAT's innovation lies in its complete autonomy. Such aerostats usually require full-time ground crews to deploy, land, and adjust. But the BAT automatically adjusts to optimal wind speeds and self-docks in case of emergencies, eliminating the need for manual labor. When winds are low, typically we want to go as high as possible — because, generally speaking, the higher you are, the stronger the winds. But if winds get too high, above the maximum capacity of the turbine, there's no reason to operate in those very strong winds, so we can bring it down, where it operates at rated power, but is not subject to very strong winds.

BAT has a power capacity of 30 kw and can actually effectively power 12 homes that can be specifically used to power in remote areas with less access to electricity, far away from sky scrappers. It specifically uses helium to lift a lightweight turbine, but it was discovered that low pressure nitrogen weights lighter than hydrogen. Since, we are losing helium as a natural resource and as quoted by Helium Reserve Organization that we will get deprived of helium in next 40 years, so nitrogen at low pressure can be used as a substitute.

For a place like India, which is very prone to disasters which is surrounded by ocean from the three sides and has the Great Himalayas at the fourth end, being earthquake prone, and having an active volcano, India certainly needs BAT for helping out by providing electricity in the affected areas. It can be used off the grid in any remote area of India, may it be out of the way mines or in the middle of ocean for oil, BAT is capable of providing electricity to these areas than the other substitutes like diesel or some other power generating engines at comparatively cheaper rates. BAT will provide electricity at Rs.10 per kw whereas normal electricity costs Rs.15 per kw.



Helium being a scarce gas, should be used less in order to preserve it for future use as well. For 1 foot diameter shell we need 93.5 cubic feet of helium, so for a BAT of 35 foot long diameter shell we need 3272 cubic feet of helium. If we install 50 BATs every year then, by 10 years we would lose helium from our earth. Using low pressure nitrogen or hydrogen may also solve the purpose if we are to produce energy in remote areas, as there are no skyscrapers to obstruct the BAT flow because of being run at lower altitudes by use of low pressure nitrogen or hydrogen instead of helium. Its now possible to employ BAT in India successfully for providing electricity and various other services in remote areas as according to statistics BAT can run in India having high velocities even at lower altitudes because of being surrounded by oceans the three sides.