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HARNESSING HIGH ALTITUDE WIND ENERGY

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ABSTRACT

The importance of the use of renewable energy sources is obvious. But what the problem confused us, is that renewable energy unlike the fossil fuel have such high energy density which means the renewable generally was dispersed form. In other words, in order to obtain amount of the energy we need, require to exploitation a wider cover area. Therefore, scientists and companies are struggling to find high densely renewable energy as possible, which is high altitude wind energy, have very promising but not developed so much by humans. High altitude wind power is indicating the altitude between 3000 meters and 10000 meters. So far, high altitude wind power is a new renewable energy that basically not development or utilization yet, but which is an abundant reserves. High altitude wind power is a widely distributed renewable clean energy. The characterized of high-altitude wind energy is fast speed, wide distribution, high stability and perennial. Utilize high-altitude wind power can get high stability with low cost of wind power generation, which is one of the notable features for high-altitude wind power, but also is one of the most significant advantages for high-altitude wind energy compared to conventional wind energy. High altitude wind power generation equipment is more compact and flexible, far superior than the traditional fan, which equip with thick blades and the tower must be fixed in the depths of the ocean or in the ground.

I. INTRODUCTION

(AWE) technology matches our aims to advance and employ renewable energy. AWE seeks to cost-effectively tap the vast supply of wind energy available at altitudes high above the reach of conventional, ground-based wind turbines (e.g. 500-12,000 m). This paper explores the viability and implementation of AWE technology for fulfilling our energy needs. The principle to harness high altitude wind energy to generate electricity is very simple, because of the distance was increased from the earth and the friction was be reduced with the earth, then the wind speed will be gradually increase. Each doubling increase of the wind speed, the energy it contains will be increase 8 times in theory.

Airborne wind energy system has large area of application in producing electricity by using different forms of AWE system. One of them is the balloon type airborne wind turbine which would be the best option in attaining the target of wind energy.

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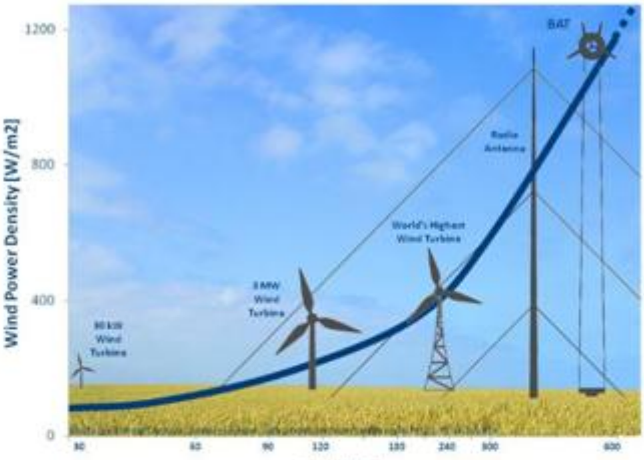

Figure1: Increas in Power capacity

A.System Discription

Renewable energy resources are abundant in nature across the globe. These renewable energies would be the key towards the development of nation and they are the only option that can mitigate the energy demand in a climatically sustainable way. Excitement among researchers about Airborne Wind Energy

1) Kite type**-** The rotational moment of kite will drive the large alternator to produce electricity**.** Kite goes up with unrolling the cable, connecting both alternator and kite, and the rotational motion of rotor produces electricity in alternator. After achieving maximum length of cable, alternator rotates in reverse direction to roll it back. The area covered by kite during generation is more due its crosswind movement. Power generated by alternator in unrolling is more than in rolling movement.

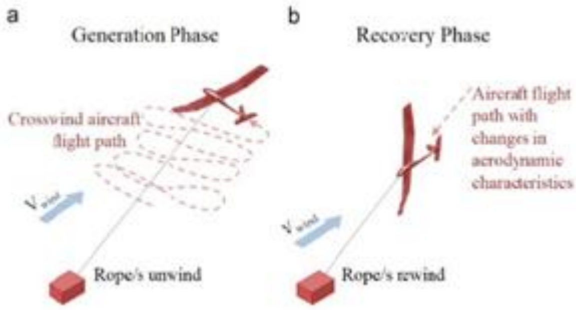

Figure2: Kite type with two phases

2) Tethered Rotorcraft (TRC) Type- It is the combination of the light weight aircraft with four rotors, to connect the power station by the cable. Electricity is provided from ground to fly up to a height (10000m). After attending that height operation rely on rapid jet stream. In case of TRC across the rapid jet streams, rotation of blades will supply lift and power, then transmit the electricity back to the power station by the cable.

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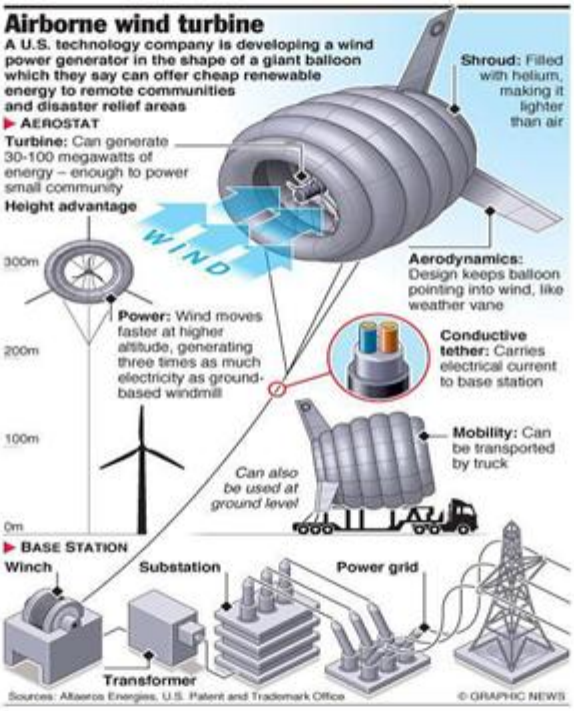
Figure 3, Tethered rotorcrafts

3) Balloon Type- In this type electricity is generated at the sky and then transmitted back to ground base by the cable. It is designed to survive 100+ mph and operate in heavy precipitation. A secondary conductive path within the electromechanical tether grounds the system and protects sensitive electrical equipment from lightning current surge. The generator is surrounded by helium balloon to give lift. This could translate to an overall cost for energy production per KWh to be less than the cost of energy from the ground-based systems.



II. MATH

The following data shows the definition of various variables used in this model:

For change in air density with increase in height,

p_0 = sea level standard atmospheric pressure, 101.325kPa T_0 = sea level standard temperature, 288.15K

g = earth surface gravitational acceleration, 9.80665 m/s^2 L = temperature lapse rate, 0.0065K/m

R = ideal (universal) gas constant, 8.31447 J/(mol.K)

M = Molar mass of dry air, 0.0289644 kg/mol

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Temperature at altitude h meter above sea level is approximated by the following formula,

$T = T_0 - Lh$ …(1)

The pressure at altitude h is given by, $p = p_0 (1 - Lh/T_0)^{gM/RL}$ …(2)

Density can then be calculated according to a molar form of ideal gas law,

$\rho = pM/RT$ …(3)

Kinetic energy of air is calculated by formula, $P = ½ * \rho * A * V^3 * C_p$ …(4)

Where, ρ= air density

A= swept area of wind turbine

V= velocity of win

C_p= power coefficient

The swept area of the turbine can be calculated from the length of the turbine blades using the equation for the area of a circle:

$A = \pi * r^2$

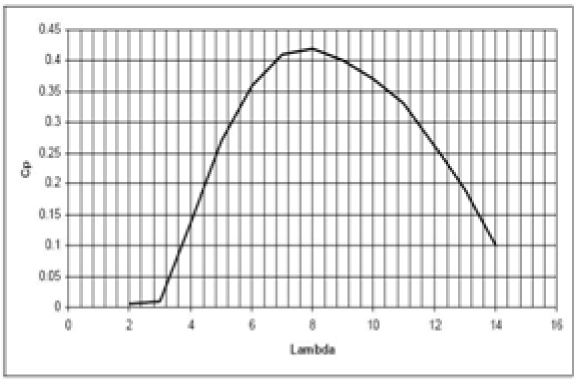
The power coefficient is not a static value as defined in the main question; it varies with the tip speed ratio of the turbine. Tip speed ratio is defined as:

λ = blade tip speed / wind speed

The blade tip speed can be calculated from the rotational speed of the turbine and the length of the blades used in the turbine using the following equation:

blade tip speed = rotational speed (rpm)*π*D/60 …(5)

C_p and λ relationship is shown in the following graph,



III. CALCULATONS

For predefined parameters

h= 600m, D= 16m, rotational speed = 500rpm

air density at 600m,

T =284.25 …from (1)

P=94.3228 kPa …from (2)

ρ=1.1559 kg/m^3 …from (3)

Blade tip speed= 393m/s

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wind Speed (m/s)	λ	Cp	Power(MW)
38	10.34	0.355	1.989
42	9.35	0.39	2.957
46	8.54	0.41	4.075
50	7.86	0.42	5.36
54	7.27	0.41	6.593
58	6.77	0.4	7.97
62	6.33	0.37	9.006
66	5.95	0.35	10.276
70	5.61	0.32	11.21
74	5.31	0.295	12.208
78	5.03	0.255	12.359

IV.ADVANTAGES

1) Deliver time averaged output much closer to its rated capacity.

2) Can be placed near to demand center, reducing transmission line cost and transmission line loss.

3) Can operate in wind speeds between 5-65 mph.

4) Can be raised to high altitudes without having to build an expensive tower.

5) Can be easily moved to different location.

V. CONCLUSION

- This paper reviews the current situation of high altitude wind power, analysis the wind speed at the altitude between ground and 10000 meter.
- Wind at high altitudes can generate more power compare to the conventional wind turbine.
- In additional, this alternative energy source offers benefits such as easy deploying, low installation cost and maintenance system, and less wind fluctuations

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