BALLOON KITE AWE

Summary

A major problem with an AWE system is the launching and retrieving the system which is necessary in conditions of low wind, high or turbulent winds or for maintenance purposes. If manual launching and retrieval is used, then the size of the kite is severely limited. Alternately if an automatic launch and retrieval system is used then the cost of this equipment makes the project prohibitive. In this proposal I recommend a combination of kite and lighter than air balloon which greatly increases the size of kite which can be manually launched and retrieved. In addition, it is not necessary to retrieve and relaunch the system for periods of low or no wind.

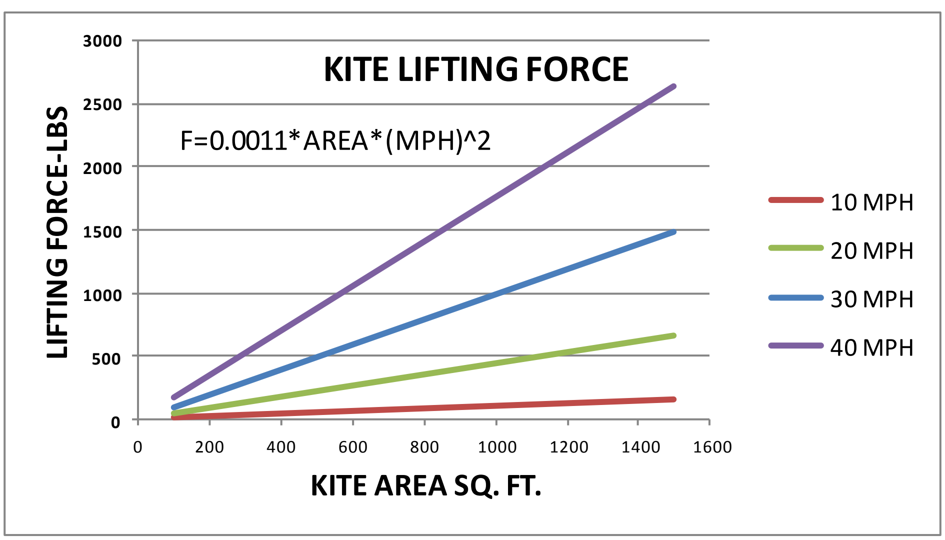
Proposal

Power will be obtained from multiple small turbines on a common axis. The power will be transferred to a generator on the ground by means of cable drives. These cables will also serve as tethers. I favor two cable drives so that the drive tension in each cable drive is halved. In addition, small adjustments in the length of each cable drive can serve as a steering mechanism for the kite.

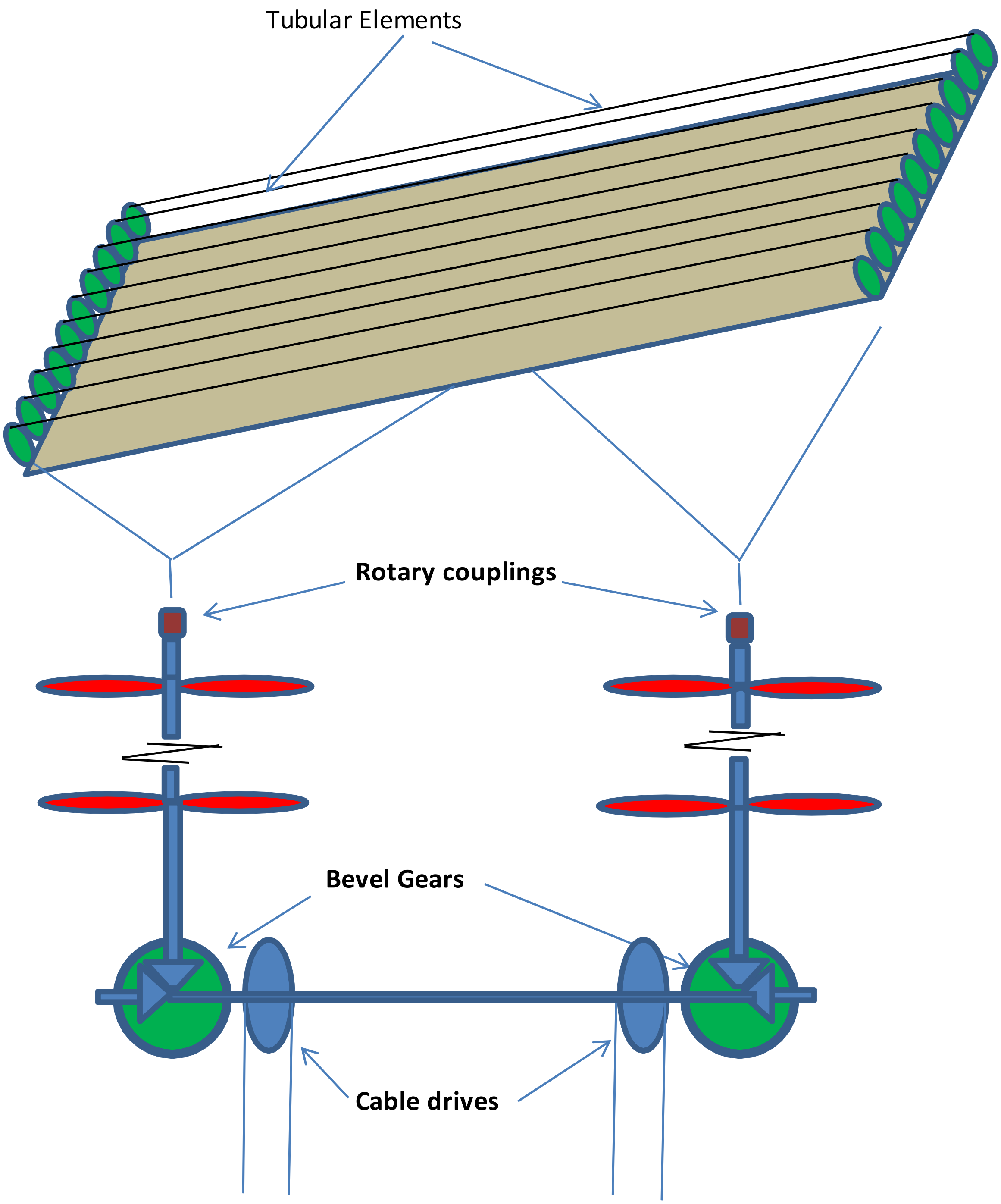
The balloon/sled kite I propose consists of a number of tubular elements ganged together. The tubes will be filled with helium or hydrogen. The buoyant force of the balloons must be enough to counter the weight of the turbines, shafts and half the weight of the cable drives. Even though this balloon kite is quite bulky, it is easily managed by a 2-3 man crew for launch and retrieval. For storage, the balloon kite can be rolled up with the tubes still inflated and placed in a trailer.

Based on Doug's Superturbine data, he obtained 2 kw using 5 turbines, 5 ft in diameter in 20 mph wind. This equates to <u>10kw using 14 turbines, 6 ft in diameter in 30 mph winds</u>. To transfer ~10kw through the cable drive we will require a differential force of 150 lbs across each drive pulley at 600 rpm. If the pulley diameters are 10" there will be no need for gear reduction. With winds at altitude of 30 mph, the lifting force of the kite is approximately 624 lbs. (Figure 1) which is considerably more than the 150 lb differential force required for the two cable drives.

Figure 1



BALLOON KITE

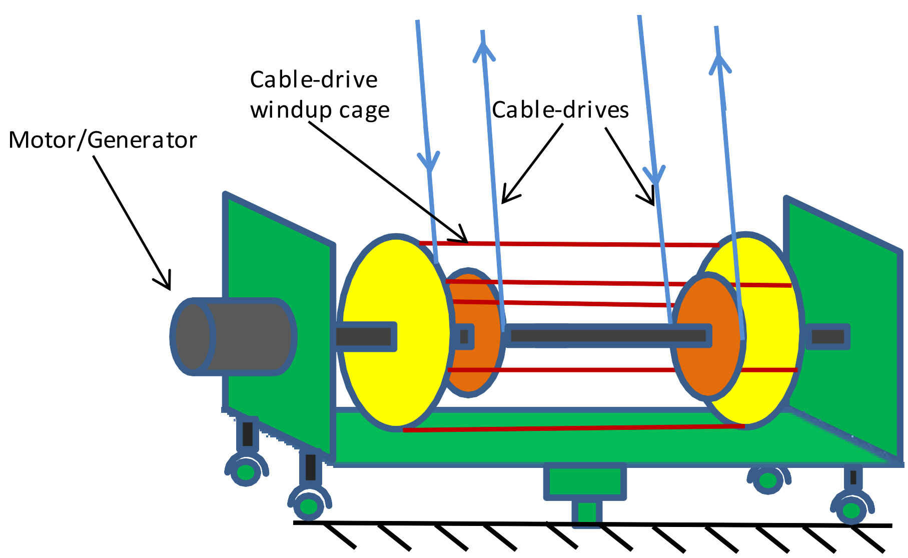


Perhaps it is advantageous to install universal joints in the shafts between the rotors to eliminate bending forces on the shafts. In this way the rotors will naturally turn to face the wind direction which will increase the power output. The penalty is that these universal joints will add to the weight of the system.

Let's assume that a 3 man crew can manually launch the kite, and that the kite can lift a payload of approximately 60 lbs. A volume of 1000 cubic feet of helium would be required to lift this payload. If this volume is distributed into 7 tubes 2 ft diameter and 45 ft long, the effective area of this balloon kite is 630 sq. ft. with a lifting force of 624 lb at 30 MPH. Retrieval and relaunch would be required for maintenance, high wind and unstable conditions, but not for conditions of low or no wind. Assume that we require 3 man-hours to retrieve and launch the system approximately once a month. Estimates of the cost of the system are as follows:

ANNUAL COSTS		
Kite + Balloons (5yr linear)	$500	
Helium(1000 cu ft@ $200/1000 cu.ft)	$200	
Cage + Generator (10yr linear)	$500	
Cables + Tether	$600	
Rotors, bevel gears, sheaves(5yr linear)	$1,000	
Retrieve+Launch (12/yr, 3 manhr@$20)	$720	
Total	**$3,520**	
Generate 10Kw 80% of the time=	70080	Kwh/yr
Energy cost=	**5.0**	**cents/Kwh**

The drive system shown below is anchored with a single point so that it easily rotates to face the wind. It can be used to rapidly retract the device in case of wind conditions which are too high or unstable. The drive motor is stopped and is used to wrap the cable drives around the cage. For normal operation, we require a method of monitoring the tension in the return cables since if the tension drops to zero, the drive may wind up and drag the system down. As mentioned above we also need a method of making small adjustments to the length of each cable drive to control the kite.



Once a suitable AWE method has been developed, we have a choice between scaling up the system, or using multiple modular units as in photovoltaic arrays and reflective mirrors in thermal solar systems. In this case, scaling up causes two critical disadvantages. Firstly, the size and weight of the shafts and drives become unacceptably heavy. Secondly, we lose the capability of manually launching. The advantage of using modular units is that we only have to test the performance of a single device to predict the performance of the whole system. (Providing modular units don't interfere with each other). Consider a 1MW system consisting of 10 rows of 10 units. If the units are spaced 30 feet apart and the rows spaced 60 feet apart, then the energy density is 6.8 Watts/sq. ft which is approximately equivalent to a photovoltaic array which operates only during the daytime.

A modular system could be much less expensive if an alternate method of power harvesting is considered. If each unit is equipped with a small hydraulic motor we could combine all these hydraulic lines in one large generator. A second method would be to link all units with cable drives. In this case, rotation of all units to face the wind would be a complication. A third method would be to have a water pump at each unit. The combined flow would be useful for emergency pumping in the case where there is a prolonged electrical outage.

Instead of using helium we could consider using hydrogen in the balloon kites. The energy of the stored hydrogen in each unit would be equivalent to about two gallons of gasoline. In the case of ignition, the balloons would rapidly burn with a vertical flame and adjacent units would not be affected. In addition to being about 1/3 the cost of helium, the permeation rate through the balloon is much less due to the molecular nature of hydrogen.

Open-AWE_IP-Cloud

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