Using Kites to Generate Electricity: Plodding, Low Tech Approach Wins

Electrical power generation using kites has been given a preliminary study by David D. Lang Associates, Seattle, on behalf of the Drachen Foundation. As its mandate, the Foundation seeks to increase and diffuse knowledge about kites worldwide.

The study spans power levels from municipal to small domestic applications. Five schemes for power generation were identified and examined.

They were evaluated with 12 criteria: maximum power potential, scalability (ability to accommodate a range of power), practicality, potential for autonomous operation, manufacturing cost relative to return on investment, prototyping cost, complexity, safety relative to design intent, environmental impact, accommodating wind variability, probability of success when demonstrated, and probability of operational success.

For convenience, the schemes were dubbed Ladder Mill, Reel, Fly Gen, Buggy, and Sail.

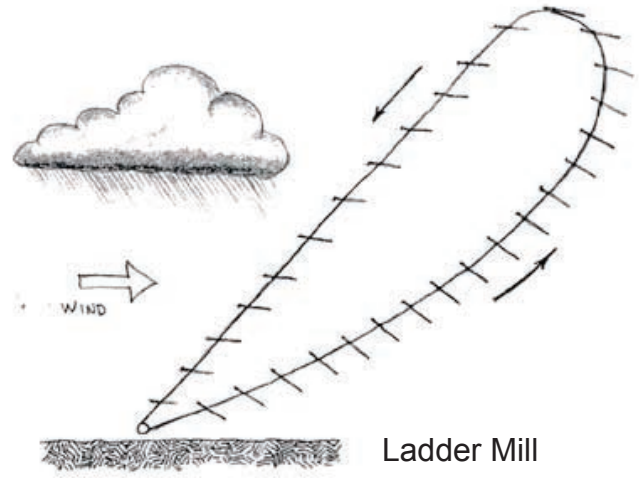
Ladder Mill. This is a continuously circulating loop of kites envisioned as flying up to altitudes of 30,000 feet. Kites on the up-bound or power side operate at full lift angle of attack creating high tension on the up-bound cable, kites on the down-bound or return side of the loop operate at near zero angle of attack, thus creating low tension on the retrieve cable. These tension differentials on the order of 10,000 pounds when applied to a capstan on the ground (like a belt around a pulley) can generate significant shaft torque to turn generating machinery. The cables would be made of carbon nanotube, which is on the order of 230 times stronger than steel on a strength per weight basis.

Reel. A plodding, low tech approach, this alternative envisions a stable kite with hard, steady pull. The kite is simply reeled out, then in, using a capstan connected to a generator. During the reel-out or power stroke, the kite pulls a maximum load. It is then depowered and reeled back. Power is harvested from the net energy gained during reel out, less than required to reel in. Electrical and mechanical components required are simple.

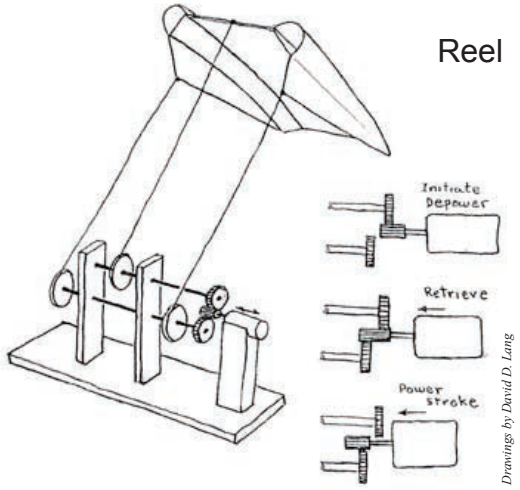
Fly Gen. This scheme harnesses the power experienced in traction kiting. It depends upon a maneuver common to traction kiting, the figure-8, in which the kite dives from high to low altitudes, trading potential energy (altitude) for kinetic energy (speed). The resulting increase in speed induces high relative winds at the kite and thus high dynamic pressures which result in high lift on the kite, experienced as high tension in the kite lines. A kite with high lift-to-drag ratio is critical to the success of this technique. Scaling up power output will be possible only via increased kite size. Adding kites or stacking is not an option since the control system is not practically attainable. Note that this scheme is unique in the fact that it is the only one in which the generator goes aireborne (thus the name Fly Gen).

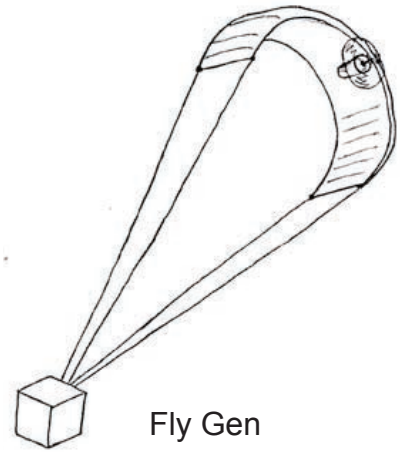
Buggy. As with Fly Gen, figure-8 maneuvers are used. The question becomes, can transient high tension periods be converted into real power? This can be achieved only if the kite is given velocity along the direction of the kite line, this being the direction of the tension. A reciprocating ground mechanical device would be needed to harvest power in this scheme.

Sail. This scheme is a kind of ground-based harnessing of the power inherent in nautical sailing technology. The pulling element is a movable ground-based mast with sail that is trimmed to the optimal point of sail. The mast and sail are mounted on a movable member that reciprocates perpendicular to the wind. With the sail at an

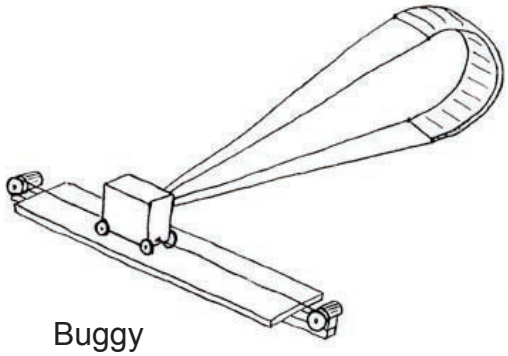


Ladder Mill

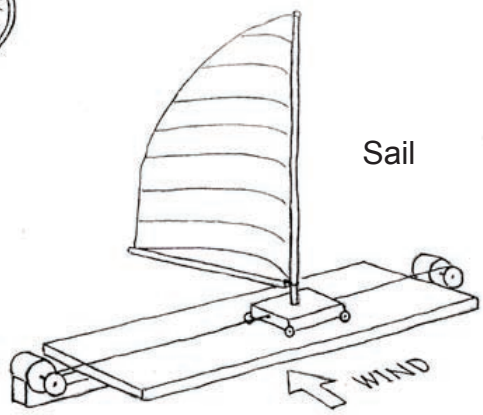




Fly Gen



Buggy



angle to the wind, the side-load moves the slider, activating the reciprocating mechanism to harvest the power, via cable arrangements and capstans putting torque on a generator. Power is generated in both directions of the reciprocating cycle.

Ratings were based on a scale of 1 to 10 with l representing "bad" and 10 "best." Specific kite foil technology was not addressed, viz. is the Sled more efficient than an Inflatable for a particular scheme?

On a scale of 100, Dave Lang rated Reel at 86 points, Sail 70, Ladder Mill 61, Fly Gen 60, and Buggy 45. "I tried to evaluate these schemes impartially," he says. "I would gracefully entertain challenges to the high score I have awarded the Reel, since I introduced it."

Reel scored 8s or 9s out of 10 in 8 of the 12 criteria categories. Sail scored only two 8s, but had a solid ranking down the line. Ladder Mill had the only 10----two of them in fact, for potential and scalability----but drew five poor ratings, including 2s for practicality, complexity, and wind variability.

Lang has written a fascinating report on the experiments he conducted and will be pleased to send it to those requesting a copy: SeattleDL@comcast.net.

About the Inventors

Inventor of the **Ladder Mill**, Wubbo Ockels is a professor at the Delft University of Technology in Holland. Ockels flew a Space Lab mission in l985 on behalf of the European Space Agency. Ockels vigorously encourages student interest in science and headed a team that won a solar car race across the Australian desert.

Dave Lang, inventor of the **Reel** scheme, was long involved in crew training and flight simulation in NASA's space flight program. He has been an independent consultant for two decades, working on everything from Learjet landing gear loads to automated turbine blades for a Columbia River power plant. The Seattleite has been the leader of a Cajun and Zydeco band for 25 years.

Peter Lynn is a pioneer in "extreme" kite sports such as land buggying and ocean kite sailing. His **Power Gen** concept follows from this work. The New Zealander is considered the leading kite showman in the world with his enormous soft kites and is among the top scientific theorists in the sport.

Inventor of the revolutionary four-line stunt kite aptly dubbed the Revolution, Joe Hadzicki, of San Diego, is the father of the **Buggy** electrical generation scheme. He is a prolific inventor and a business entrepreneur. In addition to designing kites, Hadzicki is pursuing the application of carbon fiber technology in a number of fields.

Jose Sainz, of San Diego, who conceived the **Sail** power generating scheme, has repeatedly won major honors at American Kiteflier Association conventions for his beautiful appliqué creations. He was a natural from the beginning. Only three years after taking up kitemaking, he won the association's "triple" in l992----first prize in class, grand championship, and people's choice. Sainz is famed for using images that pay honor to his Hispanic-Aztecan heritage..

Secrets of the Sky ----How Kites Fly

Without diminishing the unique magic of a kite in flight, what actually enables it to fly, to remain suspended in the sky, escaping earth's gravity?

Although the kite has been around for thousands of years, the answer to this question of an object which flies is relatively recent. There are adherents to several scientific opinions, but the most generally accepted is one posited in 1738 by a Swiss mathematician, Daniel Bernoulli, who stated that "fluids in motion exert less pressure on their surroundings the faster they move." For the kite's flight, the key lies in the kite's angle of flight which divides the passage of air above and below the kite plane. Bridle lines attached to a flying line (a kite is a tethered aircraft) are set so that the kite's front edge is higher than the back. The causes the normal stream of air molecules (wind) through which the kite passes to be broken into two halves; air jumps over the top surface, speeding up, causing a low pressure area, while on the bottom surface, the air, comparatively speaking, is slowed down, creating a high pressure area pushing upward. The difference in high and low pressure is very slight, but sufficient to give the kite lift------a kind of vacuum above and push below to fill that vacuum. This aerodynamic principle is precisely the same as that of an airplane wing, a boat sail (generating a force which moves the boat forward), and a bird's wing. (Tal Streeter, Art That Flies)