

KiteGen—Latest in Green Technology for Power Engineering

Abhishek Karan

*Department of Electrical Engineering,
Birla Institute of Technology, Ranchi, Jharkhand, India
E-mail: abhishekkaran92@gmail.com*

Abstract

KiteGen or Kite Power is a cost-effective renewable energy solution with a low environmental footprint. KiteGen is a concept developed in Italy for a wind harnessing machine that takes power from high altitude winds. The vertical axis orientation of the rotation is intended to eliminate the static and dynamic problems that prevent the increase in size of conventional wind turbines. In this paper we will discuss how KiteGen or Kite Power has emerged as a latest technology to produce renewable energy from the wind. In this paper we will also discuss the methodology, challenges and advantages of Kite Power.

Keywords: *KiteGen, Kite Power, Renewable energy, Wind Power*

INTRODUCTION

The KiteGen was originally conceived by Italian researcher Massimo Ippolito. While observing kite surfers he noticed the large amount of energy that the kite was able to collect and thought that a similar system could produce electricity. This idea seemed to Ippolito so risky that he put it aside for some years.

The problem of "capturing" the wind is solved by the use of Power Wing Profiles (Power kites) whose movements are controlled automatically by a computer.

Through cables the kites are anchored to a structure that rotates, generating electricity. This structure is the turbine of the high altitude wind farm while the kites are the "blades" of the turbine.

The kites are flown on a predetermined trajectory, that can transform the exerted force on the cable, to an overall mechanical torque which rotates the vertical axis turbine. About twenty automatically controlled kites can keep rotating a turbine of 1,600 meters diameter at a speed of 15 revolutions per hour. This

can generate 1 Gigawatt of power, equivalent to a medium size nuclear power station but with an estimated capital cost 10 times lower. In other words, 1 cubic Km of sky is able to provide 1 GigaWatt of power for 80% of the time in a year.

The kites extra added benefit lies in the fact that the length of cables allows them to reach heights over 500 meters, where the high altitude wind flows, without introducing structural weaknesses.

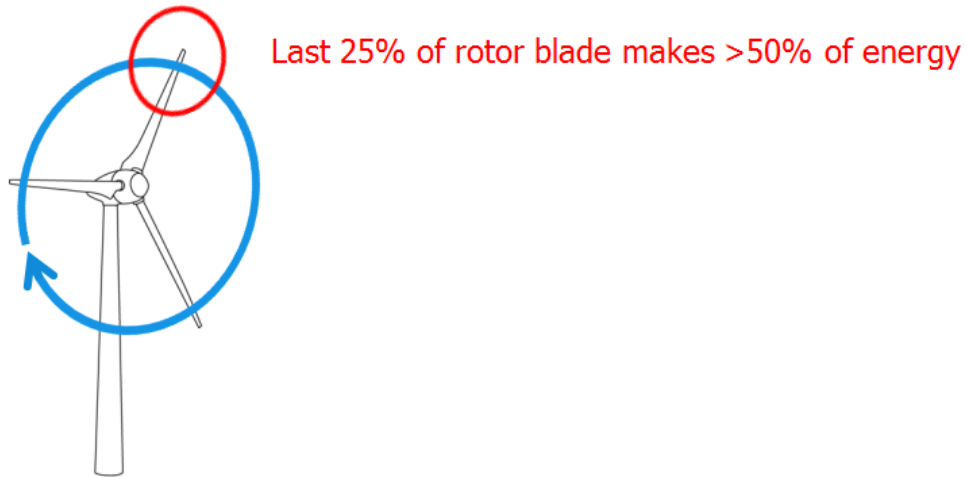


Figure 1

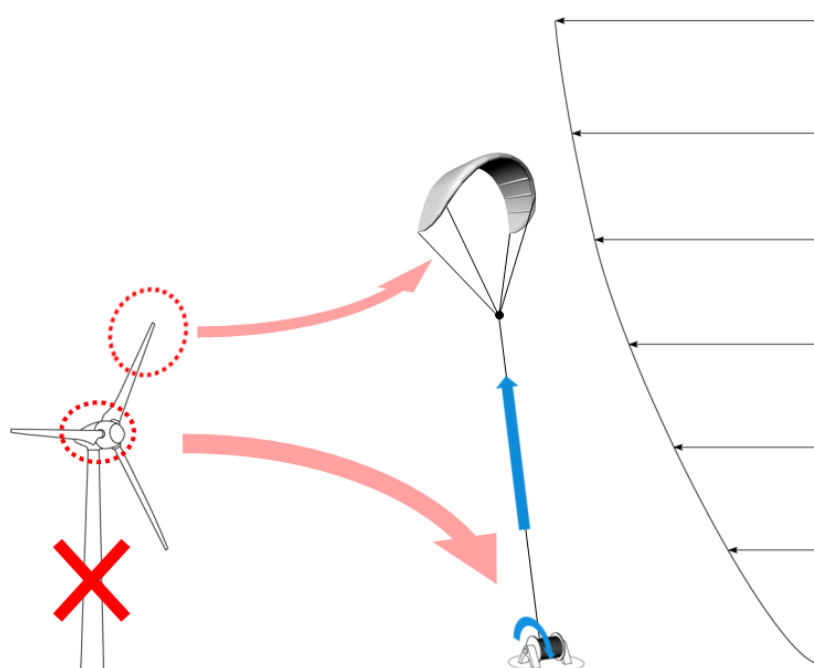


Figure 2

SOME ENGINEERING HISTORY

Humanity has used wind as a source of energy for thousands of years. According to written records from the Code of Hammurabi, the earliest windmills were built more than 4,000 years ago. In Europe, the first mentions of wind-powered mills date to the middle of the 9th century in England; and to at least 11th-century France. By means of windmills, wind energy was used to provide mechanical work.

Today, wind power is one of the fastest-growing power sources in the world. So far, the bulk of this growth has been in the form of conventional wind turbines—rigid systems with rather limited maneuverability. Although modern devices can be “downwind tracked,” this is only possible around the turbine’s vertical axis, which implies that only a rather small part of the available wind energy can be harvested. To increase efficiency, wind turbines must grow in size—and the bigger the device, the bigger the rotor blades needed to increase the yield. The machines must get bigger for another reason as well: at higher altitudes they encounter stronger and more steady wind regimes. Consequently, the towers that support the blades have grown from 50 meters in the 1990’s to about 80 meters in the 2000’s

and about 100 meters today. Some devices operate at heights up to 150 meters, but structural constraints and technical limits hamper going much higher.

But there’s another way to get way up to the place where the wind always blows. Instead of trying to harvest wind energy near the Earth’s surface, where the winds are volatile and the wind speed is low, researchers seek to go where the wind is blowing constantly and the wind speed is much higher—several hundred or even several thousands of meters above ground. (Wind speed is crucial for the amount of energy a wind turbine can convert to electricity: The energy content of the wind varies with the third power of the average wind speed. Consequently, for example, if the wind speed is doubled, its energy content is eight times as high.)

METHODOLOGY

A Swiss research consortium called SwissKitePower has been working on this form of renewable energy from wind power, as have engineers at KiteGen, on the other side of the Alps in Italy. The two teams have different approaches, but the general overall premise is roughly the same. The thinking is that at higher altitudes, wind power is stronger and more consistent—but more inaccessible. Large

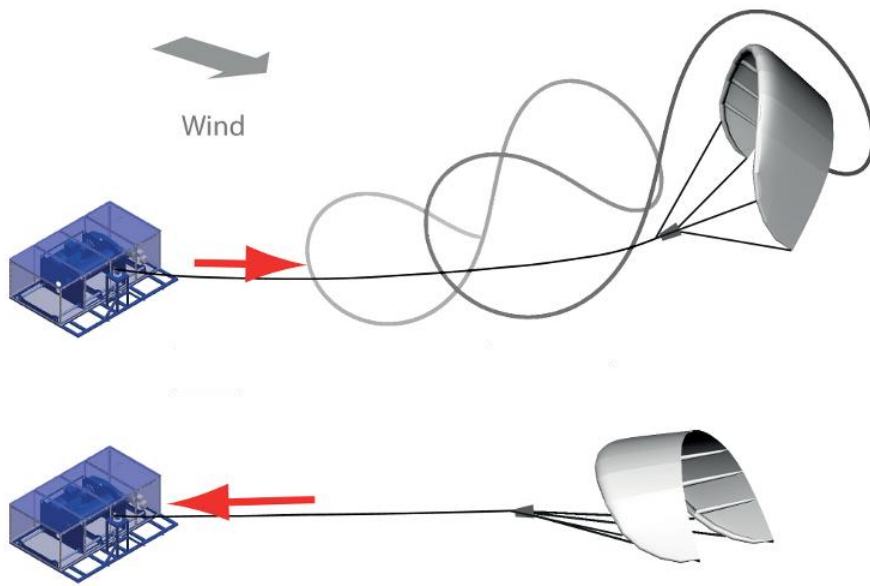


Figure 3

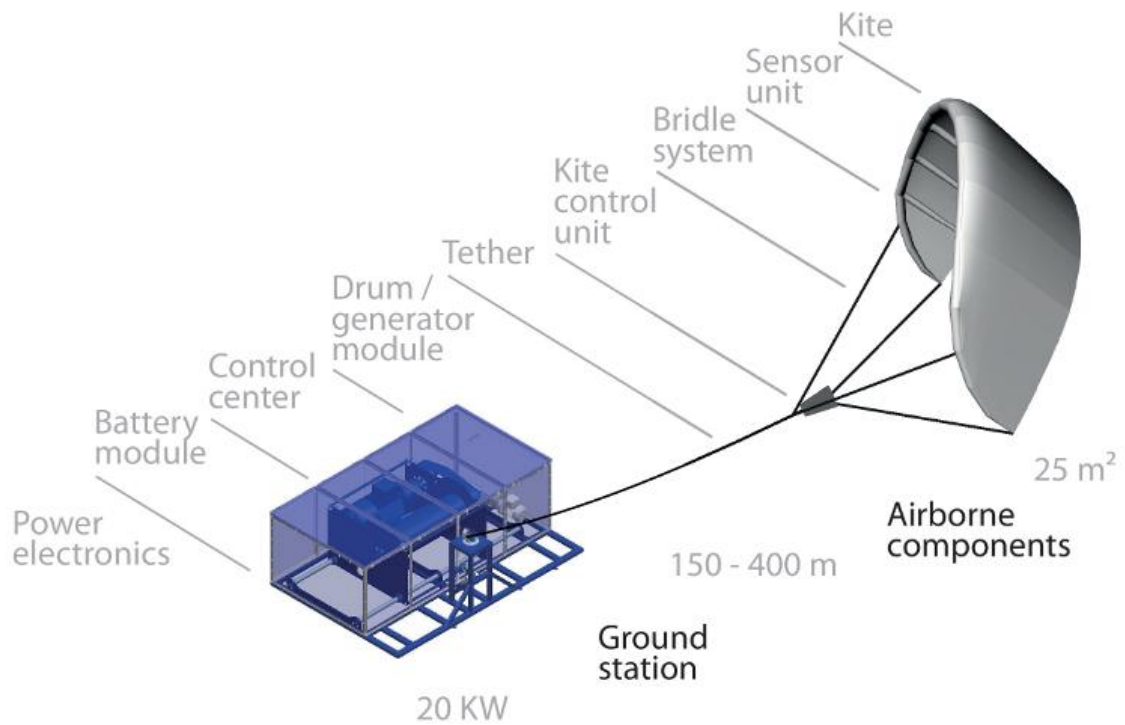


Figure 4

kites, however, could go up hundred of meters, or even kilometers, where they could readily collect the vast amounts of energy available at these heights. As the kite climbs, it would pull a line wound around a drum. As the drum spins to let out the line, it is coupled to a generator, which produces electricity. After the kite has reached a high enough altitude, the kite's angle to the wind is reduced—much like a sailor on the lake luffs a sail—causing the kite to spill wind out of its wings and descend, during which the line is reeled back in with minimal tension and thus minimal expenditure of energy. Once descent is complete, the kite is allowed to climb once more, where it generates electricity once again.

HOW DOES IT WORK?

A kite is essentially a light and controllable aerodynamic flying device that flies in a cross wind and receives wind energy; in a kite power system this energy is somehow transported via a cable apparatus to a nearby ground station. The system may be operated in periodic pumping cycles, alternating between reel-out and reel-in of the tether. During reel-out, the kite is flying figure-eight maneuvers at high speed (70 to 90 km/h). This creates a high traction force (3.1 kN at 7 m/s wind speed) which is converted

into electricity by the drum and the connected 20 kW generator. When reaching the maximum tether length, the kite is de-powered by releasing the rear (steering) lines such that the whole wing rotates and aligns with the apparent wind. Using the drum/generator module as a winch, the kite is now pulled back to the initial position to start the next pumping cycle. De-powering reduces the traction force during reel-in by 80% and for this reason the energy consumed during reel-in is only a fraction of the energy generated during reel-out. Crucial element of the technology is the automatic control and synchronization of the drum/generator module and the flight dynamics of the kite. As Shown in Fig 3 and Fig 4.

INVESTIGATIONS

Currently there are several different systems under investigation. One system converts wind directly into electricity by small turbines attached to the kite. The electricity is transported from the kite to the ground station by an electric cable.

A more frequently investigated system operates much like what happens when one allows a conventional kite to climb while pulling a line wound around a drum at the same time. The climbing kite creates a high traction force. As the drum rotates to pay out the line, it is coupled to a

generator to produce electricity. Upon reaching the maximum tether length, the kite's angle to the wind is reduced, so that the entire wing rotates and aligns with the apparent wind. The kite is then pulled back to its original position using the generator module as a winch and the next pump cycle is started. Depowering significantly reduces the traction force during reel-in by up to 80 percent. Thus, the energy consumed during retraction is only a fraction of the energy generated during unwinding.

CHALLENGES

Kite power systems are not available on the market yet, although the multinational electro-generating giant Alstom—manufacturer of France's TGV high-speed trains—signed on as industrial partner. Research is going on for all major components, such as the light-weight materials used for the kites and the tether. Scientists are also looking to improve the aerodynamic efficiency of the kite, and to arrange for several kites to work in tandem (including the set of a single kite's wing, a "train" arrangement for several kites at a time, and a "stack" configuration), the ground station, and so forth. A prerequisite for the successful commercialization of any kite power system is that it have automatic control, and synchronization of

the drum/generator module for autonomous operation.

Such things call for a lot of collaboration from different fields. In the case of the Swiss program, a mobile testing program was developed by the University of Applied Sciences Northwestern Switzerland; EMPA—a research institution affiliated with the Swiss Federal Institute of Technology-Zurich (ETH Zurich)—created the new kites; and ETH-Zurich and the Swiss Federal Institute of Technology in Lausanne developed the control system. The research gets so complicated, with the need for so many players, because so much is going on: During operation both the kite and the winch must switch between different modes of operation—reel-out phase, upper transition phase, reel-in phase, and lower transition phase. These different operation cycles are accompanied by several boundary conditions, among them maximal force, maximal acceleration, minimal and maximal height, and maximal cable length. The kite controller has to provide input for the desired elevation angle of the kite and its orientation with respect to wind direction. The aim during the reel-out phase is to maximize power generation without exceeding the maximum in acceptable design forces.

ADVANTAGES

Besides being “technically immature,” other factors hamper market penetration. As for any new technology, there are skeptics who forecast that the technology will not be socially accepted, citing the fears of interference with air traffic, shadows on the ground cast by the kites, noise from the ground station, or very low system design. The biggest concern of all is that a kite-based system would be impractical, because it could never replace a conventional power plant.

But a lot of energy can be harvested with a kite. Kite power systems can be considered as modular, flexible, small-scale power production plants. They could therefore be applied to single family houses, used for autonomous electricity production for events such as open air outdoor gatherings, and in the provision of electrical power for remote buildings such as alpine huts, settlements, and villages not yet connected to the power grid.

At the other side of the scale, it is possible to install huge power plants on the level of megawatts or even gigawatts. The Italian firm of KiteGen, located on the other side of the Saint Bernard pass, for example, developed a prototype with 27 megawatts of peak power in Turin. A configuration

with 100 megawatts of peak capacity allows production of 500 gigawatt-hours per year, enough to supply 86,000 households. The no-fly safety zone over a nuclear power plant would be sufficient for one gigawatt of installed power. The potential is amazing!

And the price of the electricity that would be generated is quite reasonable; KiteGen estimates that a 100-megawatt plant would produce electricity at a cost of about 0.03 euros (about 3.2 US cents) per kilowatt-hour. That’s a fair price, considering that there are almost no direct emissions—which means no radioactive waste materials, no carbon dioxide, no particulate matter, no nitrous oxides, and no sulphur oxides.

Supporters say that this technology is not limited to high-altitude places like Switzerland or the Italian Alps. Instead, kite technology could theoretically be applied anywhere in the world. The potential is huge: a couple of hundred meters above ground there is nearly always a steady wind.

CONCLUSION

In addition, even the problems that come along with conventional wind turbines—such as shade from the blades, accidents

with birds, noise emissions, or impairment of the natural scenery—are negligible. The kites fly so high that they cast no shadow on the ground, there is no noise, and the kites are so far away that they are almost invisible. The kite power system has a much lower material intensity compared to conventional wind turbines, which need huge concrete foundations and tons of steel for the tower and the blades. In addition, there is no reliance on scarce metals or rare earth elements like neodymium for the magnet in a wind power plant. It can therefore be assumed that the environmental footprint is very much in favor to this technology.

If we keep all these facts in perspective, the only negative point is that the technology is not on the market yet.

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